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ABSTRACT

These instructional materials are designed to improve instruction in Gas Metal Arc Welding (GMAW) and Flux-Cored Arc Welding (FCAW). The following introductory information is included: use of this publication; competency profile; instructional/task analysis; related academic and workplace skills list; tools, materials, and equipment list; and eight references. Three units of instruction are included: (1) GMAW orientation and safety; (2) GMAW equipment, applications, and techniques; and (3) FCAW. Each unit contains some or all of the following sections: objective sheet; suggested activities; assignment and written test answers; written test; unit evaluation form; teacher supplements; transparency masters; information sheet; student supplements; assignment sheets; job sheets; and dissemination material. (NLA)

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Gas Metal Arc Welding
&
Flux-cored Arc Welding

Second Edition

ED348487

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- Safety
- Equipment
- Techniques
- Job Sheets for basic joints in all positions
- Ferrous and nonferrous applications

Teacher Edition

CE 061 676

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MAVCC

Gas Metal Arc Welding and Flux-Cored Arc Welding

Second Edition

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Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition

Teacher Edition

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Foreword

Gas metal arc welding and flux-cored arc welding introduce students to high deposition welding and processes for "shielding" a weld. Because of their speed and weld quality, GMAW and FCAW are popular processes with a variety of industries. Students who master these vital welding processes will enhance their employability skills.

Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition retains a substantial amount of the original publication. Definitions and symbols agree with AWS standards and valuable troubleshooting information has been added at several points in the text.

These instructional materials are designed not only for student use, but to assist teachers in improving instruction. Sequencing of components in the introductory materials and units of instruction are the biggest change to be found in *Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition*. The written tests and transparency masters are no longer included in the student edition. Introductory materials include a competency profile, instructional/task analysis, tools and equipment list, a list of reference materials, and a summary of academic and workplace skills being reinforced in the publication.

Special attention should be given to the teacher suggestions in each unit of instruction. These suggestions present ways to increase reinforcement of academic and workplace basic skills. By reinforcing basic skills, the teacher will assist students in improving their employability skills.

As you use these instructional materials, we hope you will find they contribute to the quality of your program. We feel you will appreciate the technical changes in the second edition and the streamlined format in which it is presented. Every effort has been made to make these materials readable and by all means useable. You as a teacher, will need to develop instructional strategies for localizing, individualizing, and supplementing the text, and motivating the students who work with these instructional materials. As always, MAVCC appreciates hearing from users of our publications. Please write or call MAVCC and share what you liked about *Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition* and/or what you think needs to be changed.

Larry Nelson, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

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Acknowledgements

Appreciation is extended to those individuals who assisted with the review of the original *Gas Metal Arc Welding and Flux-Cored Arc Welding*, and contributed significantly to the development of *Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition*.

The contents of this publication were planned and reviewed by the following members of the Mid-America Vocational Curriculum Consortium *Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition* committee:

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We once again extend thanks to the members of the committee whose fine efforts helped produce the original *Gas Metal Arc Welding and Flux-Cored Arc Welding*. Additional thanks go to the manufacturers and suppliers whose procedures and graphic materials have enhanced this second edition. A special thank you to the Lincoln Electric Company and the American Welding Society for their materials and assistance.

And finally to the Oklahoma Department of Vocational and Technical Education, a thank you to personnel in word processing, art, and the print shop for their help in developing and printing a fine test.

Use of Introductory Materials

Introductory materials are included in the teacher guide only and contain useful information to assist administrators and teachers in planning for instruction.

In addition to the general information such as the table of contents, foreword, and acknowledgements page, information is included on the following:

1. **Use of this publication**—Explains the components of a unit of instruction and how they should be used as part of the teaching/ learning process.
2. **Competency profile**—Provides a record of student performance for each task included in a unit of instruction. This becomes a part of the student's permanent records and should be utilized when directing the student toward employment opportunities.
3. **Instructional/task analysis**—Provides a quick review of contents of the publication; identifies cognitive (knowledge) skills and psychomotor (doing) skills addressed in each unit of instruction.
4. **Related academic and workplace skills list**—Classifies unit tasks (assignment sheets and job sheets) according to related academic and workplace skills being reinforced. Skill areas reflected by skill groups, sub skills, and descriptions have been identified using *Workplace Basics: The Skills Employers Want*, developed by the American Society for Training and Development (ASTD) and the U.S. Department of Labor and adapted by MAVCC.
5. **Tools, equipment, and materials list**—Provides a comprehensive list of those items needed to successfully complete the assignment sheets and/or job sheets; assists administrator/teacher in determining program costs.
6. **Reference list**—Provides a comprehensive list of resources used in the development of this publication.

A glossary of terms may also be provided in the introductory materials depending on subject matter and committee recommendations.

As you use these materials, it is hoped that they will provide useful information to meet a variety of needs.

Use of This Publication

Instructional units

Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition contains 3 units of instruction. Each instructional unit in a teacher guide includes some or all of the following basic components of a unit of instruction: objective sheet, suggested activities for the teacher, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, assignment sheets, student supplements, and job sheets.

All of the unit components focus on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help to determine the following:

- Amount of materials that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for demonstrations.
- Amount of time needed for student practice.
- Supplementary materials, including print and nonprint media and equipment and supplies, that must be ordered.
- Resource people who must be contacted.

Objective sheet (Color code: White)

Each unit of instruction is based on performance objectives which state the goals for successful completion of the course. These performance objectives are stated in two forms: unit objectives which state the expected performance of each student after completion of the unit of instruction, and specific objectives which state what the student must do to reach the unit objective.

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Teachers should prepare for each unit by deciding how each objective can best be taught.

Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested activities (Color code: Pink)

This component is included only in the teacher guide. The suggested activities assist teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, and a list of supplemental resources. Ways to integrate academic and workplace skills have been included in the teacher suggestions, and skill areas have been noted in bold. (A table of academic and workplace skills with accompanying definitions has been provided on page xv.) The teacher should read the suggested activities before teaching the units and decide how each objective can best be taught. Time should also be allowed to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the teacher will vary according to the particular unit.

References used in the development of each unit are listed in the suggested-activities section, along with suggested supplemental resources that may be used to teach the unit. These materials can be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or objectives in the area covered.

Instructions for evaluating student performance on the job sheets are also included in the suggested-activities section. Teachers should select and discuss with students the rating scale that will be used.

Assignment and written test answers (Color code: Pink)

Assignment-sheet answers and written-test answers are designed to assist the teacher in evaluation of student performances.

Written test (Color code: Yellow)

This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction. The test appears in the teacher guide only, but duplication is permitted for student use. If objectives have been added, deleted, or modified, appropriate changes should be made on the written test. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired.

Unit evaluation form (Color code: White)

This sheet provides teachers with a record of each students performance on a unit of instruction. It includes space for assignment sheet ratings, job sheet ratings, written test scores, and teacher comments. The unit evaluation form is included in the teacher guide only, but may be duplicated.

Use of This Publication

Teacher supplements (Color code: White)

This component is included only in the teacher guide. Teacher supplements are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher level materials to stretch the advanced student, with remedial information or practice to assist the less-advanced student, and with state-of-the-art information in which the teacher may not have background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

Transparency masters (Color code: White)

Transparencies are included in the teacher guide only and are used to direct the students' attention to the topic of discussion. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction.

Information sheet (Color code: Green)

The information sheet provides the content essential for meeting the cognitive (knowledge) objectives of the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide information for the teaching of each objective.

Student supplements (Color code: White)

Student supplements are included in the student manual. The information presented in a student supplement may consist of tables, charts, written information, forms, or other information students will need in order to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment sheets or job sheets.

Assignment sheets (Color code: Tan)

Assignment sheets provide students with pencil and paper activities that give students the opportunity to make practical application of the knowledge in the information sheet. Criteria are provided to objectively evaluate student performance.

Job sheets (Color code: Blue)

The job sheets provide criteria to objectively evaluate student performance, a list of required equipment and materials, and a step-by-step procedure for performing a psychomotor skill. The teacher should discuss the equipment and materials available in the classroom and/or laboratory and demonstrate the procedure prior to having students practice procedure. When a student is ready to be evaluated, the teacher should follow instructions for evaluating student performance which may be found in the teacher guide.

Job sheets are an important segment of each unit. Job sheets provide potential employers with a picture of the skills being taught during training and the performances that might reasonably be expected from an individual who has had this training.

Disseminating material

Material may be given out a unit or page at a time to keep the material before the student always new. Some teachers ask students to furnish a three-ring binder or folder for the current unit of study. This is convenient for students taking the material home to study. Upon completion, each unit is then placed in a larger binder. Some teachers prefer to store the material by unit in filing cabinets or boxes until needed.

For best results, provide student materials for each student. Student manuals contain objective sheets, information sheets, student supplements, assignment sheets, and job sheets. Students should be allowed to take their materials home at the end of the course.

Academic and Workplace Skills
(Classifications and Definitions)

Skill Groups	Sub Skills	Definitions
Learning Skills	Learning to learn	Developing ability to apply knowledge to other situations; knowing how to learn.
Foundation Skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Writing	Communicating a thought, idea or fact in written form in a clear, concise manner.
	Math	Applying computation skills such as reasoning, estimation, and problem solving as they are actually used on the job.
	Science	Applying knowledge learned through study or practice that is based on scientific principles as they relate to specific tasks.
Communication Skills	Listening	Listening for content, conversation, long-term contexts, emotional meaning, and directions.
	Oral communication	Communicating a thought, idea, or fact in spoken form in a clear, concise manner.
Adaptability Skills	Creative thinking	Using imagination to create something new—i.e. an idea, invention, work of art.
	Problem solving (critical thinking)	Recognizing and defining problems, inventing, and implementing solutions, and tracking and evaluating results.
Personal Management Skills	Self-esteem	Developing self-confidence and creating a positive self-image.
	Motivation/goal setting	Setting and meeting defined goals and objectives.
	Personal and career development	Emphasizing self-direction by establishing and implementing a plan.
Group Effectiveness Skills	Interpersonal relations	Developing ability to maintain positive relations with others.
	Negotiation	Resolving conflict between two or more individuals.
	Teamwork	Working together in a group to reach a common goal.
Influence Skills	Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Leadership	Directing/influencing group in performance of a specific task; accepting responsibility for others.

Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition

Competency Profile

Name: ________________________________

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Option A

Rating scale:
4 - Skilled - Can perform job with no additional training.
3 - Moderately Skilled - Has performed job during training program; limited additional training may be required.
2 - Limited Skill - Has performed job during training program; additional training is required to develop skill.
1 - Unskilled - Is familiar with process, but is unable to perform job.
0 - No Exposure - No information or practice provided during training program, complete training required.
NA - Non-applicable.

Option B

Yes - Can perform with no additional training
No - Is unable to perform satisfactorily

Unit 1: GMAW Orientation and Safety

______1. Solve Problems about GMAW safety.
______2. ____

______Written Test Score

Unit 2: GMAW Equipment, Applications, and Techniques

______1. Set up wire on a spool-type GMAW wire feeder.
______2. Set up a flow meter and regulator for a GMAW shielding gas.
______3. Set up GMAW equipment for short-circuit transfer on mild steel.
______4. Prepare mild steel for GMAW.
______5. Use short-circuit transfer to lay stringer beads on mild steel in the flat position.
______6. Use short-circuit transfer to build a pad on mild steel in the flat position.
______7. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position.
______8. Break test a single-pass lap joint.
______9. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position.
______10. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the flat position.
______11. Bend test a welded V-groove butt joint.

______12. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position.
______13. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position.
______14. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position.
______15. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the vertical position.
______16. Use short-circuit transfer to weld to specifications a fillet weld t-Joint on mild steel in the vertical position.
______17. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position.
______18. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the overhead position.
______19. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the overhead position.
______20. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the overhead position.
______21. Set up GMAW equipment for spray transfer with mild steel.
______22. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position.
______23. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position.
______24. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position.
______25. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position.
______26. Set up GMAW equipment for spray transfer on aluminum.
______27. Prepare aluminum for GMAW.
______28. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the flat position.
______29. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the flat position.
______30. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the horizontal position.
______31. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the horizontal position.
______32. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical up position.
______33. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical up position.
______34. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical down position.
______35. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical down position.
______36. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the overhead position.
______37. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the overhead position.
______38. ______________________________

______Written Test Score

Unit 3: Flux-Cored Arc Welding

______1. Set up an FCAW wire feeder.
______2. Set up FCAW equipment for semiautomatic flux-cored welding.
______3. Prepare mild steel for FCAW.
______4. Weld to specifications a fillet weld lap joint on mild steel in the flat position.
______5. Break test a single-pass lap joint.
______6. Weld to specifications a fillet weld T-joint on mild steel in the flat position.
______7. Weld to specifications a fillet weld lap joint on mild steel in the horizontal position.
______8. Weld to specifications a fillet weld T-joint on mild steel in the horizontal position.
______9. Weld to specifications a fillet weld lap joint on mild steel in the vertical down position.
______10. Weld to specifications a fillet weld T-joint on mild steel in the vertical down position.
______11. Weld to specifications a fillet weld lap joint on mild steel in the vertical up position.
______12. Weld to specifications a fillet weld T-joint on mild steel in the vertical up position.
______13. Weld to specifications a fillet weld lap joint on mild steel in the overhead position.
______14. Weld to specifications a fillet weld T-joint on mild steel in the overhead position.
______15. Weld to specifications a V-groove butt joint on mild steel in the flat position.
______16. Weld to specifications a V-groove butt joint on mild steel in the horizontal position.
______17. Weld to specifications a V-groove butt joint on mild steel in the vertical up position.
______18. Weld to specifications a V-groove butt joint on mild steel in the overhead position.
______19. ____

______Written Test Score

COMMENTS: ____

____

____

____

____

Evaluator: ______________________________ Date: ____________________

*** Permission to duplicate this profile is granted.**

Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 1: GMAW Orientation and Safety

1. Terms and definitions
2. Advantages of the GMAW process
3. Limitations of the GMAW process
4. Principles of GMAW
5. GMAW applications
6. Benefits from learning GMAW
7. Electrical safety requirements for GMAW
8. Guidelines for duty cycle safety
9. Rules for handling cables and gas and coolant hoses
10. Rules for handling hollow castings or containers
11. Hazards associated with arc rays
12. Types of welding helmets and their characteristics
13. Guidelines for selecting a safe lens shade for GMAW
14. Protective clothing required for GMAW welding
15. Environmental safety requirements
16. Safety guidelines for working with electrode wire

17. Solve problems about GMAW safety (Assignment Sheet 1)

Related Information: What the Student Should Know	**Application: What the Student Should Be Able to Do**
Unit 2: GMAW Equipment, Applications, and Techniques	
1. Terms and definitions	
2. Characteristics of short-circuit transfer	
3. Characteristics of globular transfer	
4. Characteristics of spray transfer	
5. GMAW machine controls and their functions	
6. GMAW electrical controls and their functions	
7. Wire feeder controls and their functions	
8. Roll adjustment requirements for wire feeders	
9. Preventive maintenance requirements for wire feeders	
10. AWS classifications for electrode wires	
11. Basic short-circuit electrode wires and their characteristics	
12. Rules of thumb for GMAW electrode wire selection	
13. Guidelines for storing spools and coils of electrode wire	
14. Types of GMAW guns and their characteristics	
15. Parts of a GMAW gun tip and their functions	
16. Steps in assembling contact tips, gas diffusers, nozzles, and insulators	

Related Information: What the Student Should Know

17. Maintenance requirements for GMAW guns
18. Electrode extension and its function in GMAW
19. GMAW shielding gases and their applications
20. GMAW welding techniques and their characteristics
21. Techniques for properly ending a GMAW weld
22. Techniques for position welding with GMAW
23. Conditions that require special attention with GMAW
24. Possible causes and corrective actions for undercutting
25. Possible causes and corrective actions for porosity
26. Possible causes and corrective actions for incomplete fusion
27. Possible causes and corrective actions for incomplete joint penetration
28. Possible causes and corrective actions for excessive melt-through
29. Flow meters and their use in GMAW
30. Flow rates for GMAW shielding gases
31. Guidelines for troubleshooting GMAW problems

Application: What the Student Should Be Able to Do

32. Set up wire on a spool-type GMAW wire feeder (Job Sheet 1)
33. Set up a flow meter and regulator for a GMAW shielding gas (Job Sheet 2)
34. Set up GMAW equipment for short-circuit transfer on mild steel (Job Sheet 3)
35. Prepare mild steel for GMAW (Job Sheet 4)
36. Use short-circuit transfer to lay stringer beads on mild steel in the flat position (Job Sheet 5)
37. Use short-circuit transfer to build a pad on mild steel in the flat position (Job Sheet 6)
38. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position (Job Sheet 7)
39. Break test a single-pass lap joint (Job Sheet 8)
40. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position (Job Sheet 9)
41. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the flat position (Job Sheet 10)
42. Bend test a welded V-groove butt joint (Job Sheet 11)
43. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position (Job Sheet 12)

Related Information: What the Student Should Know	**Application: What the Student Should Be Able to Do**
	44. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position (Job Sheet 13)
	45. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position (Job Sheet 14)
	46. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the vertical position (Job Sheet 15)
	47. Use short-circuit transfer to weld to specifications a fillet weld T-Joint on mild steel in the vertical position (Job Sheet 16)
	48. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position (Job Sheet 17)
	49. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the overhead position (Job Sheet 18)
	50. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the overhead position (Job Sheet 19)
	51. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the overhead position (Job Sheet 20)
	52. Set up GMAW equipment for spray transfer with mild steel (Job Sheet 21)
	53. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position (Job Sheet 22)

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
	54. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position (Job Sheet 23)
	55. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position (Job Sheet 24)
	56. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position (Job Sheet 25)
	57. Set up GMAW equipment for spray transfer on aluminum (Job Sheet 26)
	58. Prepare aluminum for GMAW (Job Sheet 27)
	59. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the flat position (Job Sheet 28)
	60. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the flat position (Job Sheet 29)
	61. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the horizontal position (Job Sheet 30)
	62. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the horizontal position (Job Sheet 31)
	63. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical up position (Job Sheet 32)

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
	64. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical up position (Job Sheet 33)
	65. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical down position (Job Sheet 34)
	66. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical down position (Job Sheet 35)
	67. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the overhead position (Job Sheet 36)
	68. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the overhead position (Job Sheet 37)

Unit 3: Flux-Cored Arc Welding

1. Terms and definitions
2. Advantages of FCAW
3. Limitations of FCAW
4. How students benefit from learning FCAW
5. Equipment required for semiautomatic self-shielded FCAW
6. Types of flux-cored arc welding processes
7. Types of FCAW guns and their uses
8. Classifications for FCAW electrode wires

Related Information: What the Student Should Know

9. Electrode extension and visible electrode extension
10. Basic types of flux-cored wire feeders
11. Guidelines for using drive rolls and guide tubes
12. Steps for starting an arc with the semiautomatic process
13. Operating variables with flux-cored electrode wires
14. Guidelines for preparing FCAW applications
15. Guidelines for semiautomatic FCAW
16. Safety requirements for FCAW
17. Guidelines for troubleshooting FCAW problems

Application: What the Student Should Be Able to Do

18. Set up or replace wire on a flux-cored wire feeder (Job Sheet 1)
19. Set up FCAW equipment for semiautomatic flux-cored welding (Job Sheet 2)
20. Prepare mild steel for FCAW (Job Sheet 3)
21. Weld to specifications a fillet weld lap joint on mild steel in the flat position (Job Sheet 4)
22. Break test a single-pass lap joint (Job Sheet 5)
23. Weld to specifications a fillet weld T-joint on mild steel in the flat position (Job Sheet 6)
24. Weld to specifications a fillet weld lap joint on mild steel in the horizontal position (Job Sheet 7)
25. Weld to specifications a fillet weld T-joint on mild steel in the horizontal position (Job Sheet 8)
26. Weld to specifications a fillet weld lap joint on mild steel in the vertical down position (Job Sheet 9)
27. Weld to specifications a fillet weld T-joint on mild steel in the vertical down position (Job Sheet 10)
28. Weld to specifications a fillet weld lap joint on mild steel in the vertical up position (Job Sheet 11)
29. Weld to specifications a fillet weld T-joint on mild steel in the vertical up position (Job Sheet 12)
30. Weld to specifications a fillet weld lap joint on mild steel in the overhead position (Job Sheet 13)

Related Information: What the Student Should Know	**Application: What the Student Should Be Able to Do**
	31. Weld to specifications a fillet weld T-joint on mild steel in the overhead position (Job Sheet 14)
	32. Weld to specifications a V-groove butt joint on mild steel in the flat position (Job Sheet 15)
	33. Weld to specifications a V-groove butt joint on mild steel in the horizontal position (Job Sheet 16)
	34. Weld to specifications a V-groove butt joint on mild steel in the vertical up position (Job Sheet 17)
	35. Weld to specifications a V-groove butt joint on mild steel in the overhead position (Job Sheet 18)

Related Academic and Workplace Skills
For *Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition*

Task	Skill Group	Sub Skill	Description
Unit 1: GMAW Orientation and Safety			
Solve Problems about GMAW safety. (A.S. 1)	Foundation Skills	Reading	Analyzes written information
	Adaptability Skills	Problem solving (critical thinking)	Recognizes problems and creates effective solutions for them
Unit 2: GMAW Equipment, Applications, and Techniques			
Set up wire on a spool-type GMAW wire feeder. (J.S. 1)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to load a wire feeder
Set up a flow meter and regulator for a GMAW shielding gas. (J.S. 2)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to install regulating equipment
Set up GMAW equipment for short-circuit transfer on mild steel. (J.S. 3)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to make critical machine adjustments
Prepare mild steel for GMAW. (J.S. 4)	Foundation Skills	Reading	Comprehends and follows written instructions
		Science	Manipulates hand and powered tools to complete a cleaning process
Use short-circuit transfer to lay stringer beads on mild steel in the flat position. (J.S. 5)	Foundation Skills	Reading	Comprehends written specifications and applies them to a procedure
		Science	Applies knowledge learned through practice to operate a machine and complete a process
Use short-circuit transfer to build a pad on mild steel in the flat position. (J.S. 6)	Foundation Skills	Reading	Comprehends written specifications and applies them to a procedure

Task	Skill Group	Sub Skill	Description
		Science	Applies knowledge learned through practice to operate a machine and complete a procedure
Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position. (J.S. 7)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the flat position
Break test a single-pass lap joint. (J.S. 8)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Manipulates hand tools to complete a testing procedure
Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position. (J.S. 9)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the flat position
Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the flat position. (J.S. 10)	Foundation Skills	Reading	Comprehends and follows written specifications
		Math	Measures and marks beveled edges to specifications
		Science	Adapts welding skills to complete a V-groove butt weld in the flat position
Bend test a welded V-groove butt joint. (J.S. 11)	Foundation Skills	Reading	Comprehends and follows written specifications
		Math	Measures and marks metal to specifications
		Science	Manipulates hand and powered tools to complete a testing procedure
Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position. (J.S. 12)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the horizontal position

Task	Skill Group	Sub Skill	Description
Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position. (J.S. 13)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the horizontal position
Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position. (J.S. 14)	Foundation Skills	Reading	Comprehends and follows written specifications
		Math	Measures and marks beveled edges to specifications
		Science	Adapts welding skills to complete a V-groove butt weld in the horizontal position
Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the vertical position. (J.S. 15)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the vertical position
Use short-circuit transfer to weld to specifications a fillet weld t-Joint on mild steel in the vertical position. (J.S. 16)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the vertical position
Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position. (J.S. 17)	Foundation Skills	Reading	Comprehends and follows written specifications
		Math	Measures and marks beveled edges to specifications
		Science	Adapts welding skills to complete a V-groove butt joint weld in the vertical position
Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the overhead position. (J.S. 18)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the overhead position

Task	Skill Group	Sub Skill	Description
Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the overhead position. (J.S. 19)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the overhead position
Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the overhead position. (J.S. 20)	Foundation Skills	Reading	Comprehends and follows written specifications
		Math	Measures and marks beveled edges to specifications
		Science	Adapts welding skills to complete a V-groove butt joint weld in the overhead position
Set up GMAW equipment for spray transfer with mild steel. (J.S. 21)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to set-up and adjust equipment
Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position. (J.S. 22)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the flat position
Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position. (J.S. 23)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills on complete a fillet weld on a T-joint in the flat position
Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position. (J.S. 24)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the horizontal position
Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position. (J.S. 25)	Foundation Skills	Reading	Comprehends and follows written instructions

Task	Skill Group	Sub Skill	Description
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the horizontal position
Set up GMAW equipment for spray transfer on aluminum. (J.S. 26)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to set up and adjust equipment
Prepare aluminum for GMAW. (J.S. 27)	Foundation Skills	Reading	Comprehends and follows written instructions
		Science	Manipulates tools and materials to complete a cleaning process
Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the flat position. (J.S. 28)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on an aluminum lap joint in the flat position
Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the flat position. (J.S. 29)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on an aluminum T-joint in the flat position
Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the horizontal position. (J.S. 30)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on an aluminum lap joint in the horizontal position
Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the horizontal position. (J.S. 31)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on an aluminum T-joint in the horizontal position
Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical up position. (J.S. 32)	Foundation Skills	Reading	Comprehends and follows written specifications

Task	Skill Group	Sub Skill	Description
		Science	Adapts welding skills to complete a fillet weld on an aluminum lap joint in the vertical up position
Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical up position. (J.S. 33)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on an aluminum T-joint in the vertical up position
Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical down position. (J.S. 34)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on an aluminum lap joint in the vertical down position
Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical down position. (J.S. 35)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on an aluminum T-joint in the vertical down position
Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the overhead position. (J.S. 36)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on an aluminum lap joint in the overhead position
Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the overhead position. (J.S. 37)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on an aluminum T-joint in the overhead position

Unit 3: Flux-Cored Arc Welding

Task	Skill Group	Sub Skill	Description
Set up or replace wire on a flux-cored wire feeder. (J.S. 1)	Foundation Skills	Reading	Comprehends written information and applies it to a task

Task	Skill Group	Sub Skill	Description
		Science	Applies knowledge learned through practice to set up a wire feeder
Set up FCAW equipment for semiautomatic flux-cored welding. (J.S. 2)	Foundation Skills	Reading	Comprehends written information and applies it to a task
		Science	Applies knowledge learned through practice to set up and adjust equipment
Prepare mild steel for FCAW. (J.S. 3)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Manipulates hand and power tools to complete a cleaning process
Weld to specifications a fillet weld lap joint on mild steel in the flat position. (J.S. 4)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the flat position
Break test a single-pass lap joint. (J.S. 5)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Manipulates hand tools to complete a testing procedure
Weld to specifications a fillet weld T-joint on mild steel in the flat position. (J.S. 6)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the flat position
Weld to specifications a fillet weld lap joint on mild steel in the horizontal position. (J.S. 7)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the horizontal position
Weld to specifications a fillet weld T-joint on mild steel in the horizontal position. (J.S. 8)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the horizontal position
Weld to specifications a fillet weld lap joint on mild steel in the vertical down position. (J.S. 9)	Foundation Skills	Reading	Comprehends and follows written specifications

Task	Skill Group	Sub Skill	Description
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the vertical down position
Weld to specifications a fillet weld T-joint on mild steel in the vertical down position. (J.S. 10)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the vertical down position
Weld to specifications a fillet weld lap joint on mild steel in the vertical up position. (J.S. 11)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the vertical up position
Weld to specifications a fillet weld T-joint on mild steel in the vertical up position. (J.S. 12)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the vertical up position
Weld to specifications a fillet weld lap joint on mild steel in the overhead position. (J.S. 13)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a lap joint in the overhead position
Weld to specifications a fillet weld T-joint on mild steel in the overhead position. (J.S. 14)	Foundation Skills	Reading	Comprehends and follows written specifications
		Science	Adapts welding skills to complete a fillet weld on a T-joint in the overhead position
Weld to specifications a V-groove butt joint on mild steel in the flat position. (J.S. 15)	Foundation Skills	Reading	Comprehends and follows written specifications
		Math	Measures and prepares beveled angles to specifications
		Science	Adapts welding skills to complete a V-groove butt joint weld with a backup plate in the flat position

Task	Skill Group	Sub Skill	Description
Weld to specifications a V-groove butt joint on mild steel in the horizontal position. (J.S. 16)	Foundation Skills	Reading	Comprehends and follows written specifications
		Math	Measures and prepares beveled angles to specifications
		Science	Adapts welding skills to complete a V-groove butt joint weld with a backup plate in the horizontal position
Weld to specifications a V-groove butt joint on mild steel in the vertical up position. (J.S. 17)	Foundation Skills	Reading	Comprehends and follows written specifications
		Math	Measures and prepares beveled angles to specifications
		Science	Adapts welding skills to complete a V-groove butt joint weld with a backup plate in the vertical up position
Weld to specifications a V-groove butt joint on mild steel in the overhead position. (J.S. 18)	Foundation Skills	Reading	Comprehends and follows written specifications
		Math	Measures and prepares beveled angles to specifications
		Science	Adapts welding skills to complete a V-groove butt joint weld with a backup plate in the overhead position

Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition

Tools, Equipment, and Materials List

- Adjustable wrench
- Aluminum plate
- Ball peen hammer
- Bench vise
- Bend test machine
- Face shields
- FCAW gun and components
- Fine-cut file
- GMAW/FCAW machine and accessories
    - Coolant solenoid
    - Fine voltage control
    - Flowmeter regulator
    - Gun and cable assembly
    - Inductance control
    - Power supply
    - Slope control
    - Voltage range selector
    - Wire feeder
- GMAW gun and components
- Mild steel plate
- Nozzle spray or gel
- Oxyacetylene cutting equipment
- Personal safety clothing for each student
- Portable grinder/sander
- Safety glasses
- Screwdriver
- Shielding gases
    - Argon
    - CO_2
    - Helium (optional)
    - Oxygen
- Spools and/or coils of electrode wire
    - E-70T series for FCAW
    - ER-70S series for GMAW
- Stainless steel brush
- Well ventilated welding areas
- Wire brush
- Wire feeder controls
    - Amperage/wire speed control
    - Remote unit (optional)
    - Wire-inch switch
- Wire-cutting pliers

Gas Metal Arc Welding and Flux-Cored Arc Welding, Second Edition

References

Althouse, Andrew D., Carl H. Turnquist, and William A. Bowditch. *Modern Welding, Revised Edition.* South Holland, IL: The Goodheart-Willcox Co., Inc., 1988.

Connor, Leonard P., ed. *Welding Handbook Eighth Edition, Vol. 1, Welding Technology.* Miami, FL: American Welding Society, 1987.

Fortney, Clarence and Mike Gregory. Gas Metal Arc Welding and Flux-Cored Arc Welding. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

New Lessons in Arc Welding. Cleveland, OH: The Lincoln Electric Company, 1981.

O'Brien, R. L., ed. *Welding Handbook Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.

The Procedure Handbook of Arc Welding, Twelfth Edition. Cleveland, OH: The Lincoln Electric Company, 1973.

Welding & Fabricating Data Book, 1988/89. Cleveland, OH: Penton Publishing Inc., 1988.

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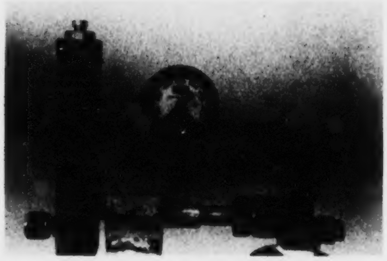


GMAW Orientation and Safety

Unit 1

Objective Sheet

Unit Objective

After completing this unit, the student should be able to define the Gas Metal Arc Welding process and solve problems related to GMAW safety. The student should demonstrate these competencies by completing the assignment sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to GMAW orientation and safety with their correct definitions.
2. Complete statements about the advantages of the GMAW process.
3. Select true statements about the limitation of the GMAW process.
4. Complete statements about principles of GMAW.
5. Solve problems about GMAW applications.
6. Select true statements about benefits from learning GMAW.
7. Select true statements about electrical safety requirements for GMAW.
8. Select true statements about guidelines for duty cycle safety.
9. Solve problems about rules for handling cables and gas and coolant hoses.
10. Complete statements about rules for handling hollow castings or containers.
11. Select true statements about hazards associated with arc burn.
12. Complete statements about types of welding helmets and their characteristics.
13. Complete statements about guidelines for selecting a safe lens shade for GMAW.

Objective Sheet

14. Select true statements about protective clothing required for GMAW.
15. Complete statements about environmental safety requirements.
16. Select true statements about safety guidelines for working with electrode wire.
17. Solve problems about GMAW safety. (Assignment Sheet 1)

GMAW Orientation and Safety
Unit 1

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.
2. Review Teaching Suggestions that follow. Plan for classroom activities.
3. Plan for special needs students.
4. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.
5. Develop a teaching plan. Adjust for different learning styles.
6. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.
9. Discuss unit and specific objectives.
10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
11. Discuss assignment sheets. Review criteria for evaluation of these activities.

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
13. Make copies of the written test. Add or modify test questions as needed.
14. Give written test.
15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.
16. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These ASTD skill areas have been adapted by MAVCC.

1. Use Objective 6 to impress students with the career benefits that come with skills in gas metal arc welding. Find shops or industries in your area that use the GMAW process. Have welders from those businesses talk to the class about the advantages of having GMAW skills. Skill areas: **personal management skills, personal and career development**.

2. When teaching Objective 8, stress the importance of the welding machine and other electrical components in the GMAW process. Since GMAW requires articulate electrical settings and adjustments, students should learn to appreciate the "machine" as an extremely important part of the process. Skill areas: **foundation skills, learning to learn**.

3. Be sure to demonstrate how to work with electrode wires when you get to Objective 16. Improperly handled wires contribute to personal injury and, sometimes, destruction of valuable supplies. Skill areas: **foundation skills, learning to learn**.

Resources Used in Developing This Unit

1. Connor, Leonard P., ed. *Welding Handbook Eighth Edition, Vol. 1, Welding Technology.* Miami, FL: American Welding Society, 1987.

2. O'Brien, R. L., ed. *Welding Handbook Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.

3. *1988/89 Welding & Fabrication Data Handbook.* Cleveland, OH: Penton Publishing, Inc., 1988.

4. *The Procedure Handbook of Arc Welding, Twelfth Edition.* Cleveland, OH: The Lincoln Electric Company, 1973.

5. *New Lessons in Arc Welding.* Cleveland, OH: The Lincoln Electric Company, 1981.

6. Fortney, Clarence and Mike Gregory. *Gas Metal Arc Welding and Flux-Cored Arc Welding.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

Suggested Activities

Suggested Supplemental Resources

1. HOB-10, GMAW Basic, and HOB-11, GMAW Advanced. Basic program has 21 topics, advanced program has 14 topics. Available in videocassette tapes, ½″ VHS, and other formats. Contact:

   Hobart School of Welding Technology
   Trade Square East
   Troy, OH 45373

2. KEN-3, MIG, Gas Metal Arc Welding training program. Six programs ranging from basics through electrode wires, shielding gases, and welding guns. Come complete with a Millermatic 35 power source. Contact:

   Ken Cook Education Systems
   12855 West Silver Spring Drive
   P.O. Box 207
   Butler, WI 53007
   800-362-2662

3. SICA-5, Metal Transfer in the Gas Shielded Arc Welding of Steel. Available in videocassette, or ¾″ U-matic. Contact:

   SICA Productions
   1459 St. Georges Avenue
   Rahway, NJ 07065
   201-382-0618

4. VTR-3, GMAW & GTAW Welding. Available as 14 video tapes in a workbook/videotext format. Includes GMAW safety and equipment. Contact:

   Video Training Resource, Inc.
   7500 West 78th Street
   Edina, NM 55435-2889
   800-828-8190

GMAW Orientation and Safety
Unit 1

Answers to Assignment Sheet

Note: Students' answers should approximate those given.

a. Yes. All electrical power sources should be disconnected before working on any electrical equipment.

b. Yes. You've exceeded the safe limits of the duty cycle and should stop welding and check equipment or wait a safe time before continuing.

c. Yes. Only clean, dry rags should be used to clean cables and hoses.

d. Yes. Even though sparks may not injure you, the radiation from the arc is strong enough to sunburn or sometimes blister bare skin.

e. Yes. Always wear safety glasses when working with electrode wire because a loose end could spring up and injure an eye.

GMAW Orientation and Safety
Unit 1

Answers to Written Test

1. a. 7
   b. 5
   c. 1
   d. 8
   e. 3
   f. 9
   g. 6
   h. 2
   i. 4
   j. 12
   k. 11
   l. 13
   m. 10

2. a. Beginners
   b. Heat
   c. Always
   d. 98%
   e. Both ferrous and nonferrous metals
   f. Either automatic or semi-automatic
   g. No

3. b

4. a. DCEP
   b. Voltage
   c. Inches-per-minute
   d. A dial on the welding machine
   e. Contaminants

5. a. 3
   b. 2
   c. 1

6. a, b, c, d

7. a, b, c, e, f, g, h

8. c, d

9. a. 1
   b. 3
   c. 2

10. a. Vented
    b. Purged

11. a, b, c

Answers to Written Test

12. a. Fixed
    b. Plastic

13. a. Amperage or current
    b. Higher
    c. Darker
    d. #7
    e. One number darker

14. a, b, c, d, e, g

15. a. Toxic
    b. Oxygen displacement
    c. That are continuous
    d. Irritation, and poor work

16. a, b, c, d, e

GMAW Orientation and Safety
Unit 1

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

_____a. A GMAW process in which the welding current is continuous in a programmed application; the workpieces travels under a welding head or the welding head travels along the workpiece

_____b. That which can be used up, a way of defining electrode wires used in GMAW

_____c. The weight of filler metal placed onto or into a weld in a given period of time

_____d. An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding comes entirely from an externally supplied gas

_____e. An element that has no active properties

_____f. A nonstandard term still used in reference to GMAW

_____g. An element or gas that has properties which will actively combine with other elements present in a base metal or a filler electrode at high temperature

_____h. A GMAW process in which the welding current is completed as an operator squeezes a gun trigger

1. Deposition rate
2. Semi-automatic
3. Inert
4. Shielding gases
5. Consumable
6. Reactive
7. Automatic
8. Gas metal arc welding
9. Metal inert gas
10. Toxic hazards
11. NEMA
12. Contaminants
13. Oxygen displacement

Written Test

_____i. Inert gases such as argon or helium, or reactive gases such as CO_2, which are directed under pressure into a weld zone to protect it from atmospheric contamination

_____j. Elements in air, impurities in shielding gases, or chemical reactions between base metals and electrodes

_____k. National Electrical Manufacturer's Association

_____l. A reduction of oxygen in the breathing zone around a welding activity caused by any arc or flame

_____m. Poisonous gases, fumes, and vapors produced by chemical reactions in certain welding processes

2. Complete statements about the advantages of the GMAW process. Circle the material that best completes each of the following statements.

   a. (**Those with basic welding skills**) (**Beginners**) can be more quickly trained to weld with the GMAW process than with any other welding process.

   b. Because GMAW better controls (**deposition**) (**heat**) in the weld zone, it reduces distortion in base metals.

   c. Because the GMAW arc is (**usually**) (**always**) visible to the operator, better welds are possible.

   d. GMAW gives a high deposition efficiency with up to (**98%**) (**90%**) of the welding wire deposited in the joint.

   e. GMAW is adaptable to (**both ferrous and nonferrous metals**) (**only ferrous metals**) in all thicknesses through modification of electrode wire and shielding gas selections.

   f. GMAW is adaptable to (**only semi-automatic**) (**either automatic or semi-automatic**) operation.

   g. GMAW reduces welding costs because it usually requires (**moderate**) (**no**) cleanup.

Written Test

3. Select true statements about limitations of the GMAW process. Place an "X" beside each true statement.

   ______a. GMAW will function in a windy environment, but it requires modification.

   ______b. GMAW requires careful setting of electrical components.

   ______c. GMAW equipment is heavier than other welding equipment, but it is still highly portable.

4. Complete statements about principles of GMAW. Circle the material that best completes each statement.

   a. The GMAW process usually operates on (**DCEP**) (**DCEN**).

   b. The GMAW process is controlled by arc amperage and (**voltage**) (**wire speed**).

   c. Arc amperage in the weld zone is controlled by feeding a bare electrode wire through a wire feeder and cable assembly at a preset feed speed which is calibrated in (**inches-per-minute**) (**feet-per-minute**).

   d. Voltage is controlled by (**wire feed speed**) (**a dial on the welding machine**).

   e. As the arc is struck, a shielding gas is forced around the electrode wire and the weld zone to stabilize the arc and protect the molten filler metal and base metal from (**contaminants**) (**wind**).

5. Solve problems about GMAW applications. Circle the number of the item that best solves each of the following problems.

   a. A project calls for aluminum components. You have to decide if the GMAW process is suitable for the job. You should answer:

      (1) Definitely not.
      (2) Yes, but it should require extensive modifications.
      (3) Yes, GMAW is especially suitable for welding aluminum.

   b. A friend in an auto repair shop is thinking about buying a welding rig. Your friend wants to know your recommendation. You should answer:

      (1) Nothing beats good old stick welding.
      (2) GMAW is especially effective where fit-up is not critical, and for an automotive shop, it would be good.
      (3) Try to work with an oxyacetylene rig because they are cheaper and can do almost everything other rigs can do.

Written Test

c. A project calls for several different thicknesses of metal. You have to decide if GMAW is suitable for the job. You should answer:

(1) Definitely because quick electrical adjustments can be made to adjust the wire to the metal thickness without having to change the wire.
(2) Definitely because the wire selection can be tailor-made for every metal thickness, and changing wire is a snap.
(3) This is definitely a job for the SMAW process where electrode sizes can be changed quickly.

6. Select true statements about benefits from learning GMAW. Place an "X" beside each true statement.

______a. Working with GMAW is a good way for a student to learn the concept of a consumable electrode, and shielding gases and their uses.

______b. The GMAW process introduces students to electrical concepts and electrical controls that other welding processes do not require.

______c. GMAW gives students a better idea of what "operator control" really means in a welding process.

______d. As students work with GMAW, they will experience better visibility of the arc, electrode, and total weld zone than with other processes.

______e. Learning GMAW provides no additional job-getting skill for industry, and part-time jobs for GMAW are hard to find.

7. Select true statements about electrical safety requirements for GMAW. Place an "X" beside each true statement.

______a. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead to workpiece ground that completes the welding circuit.

______b. Keep electrical connections tight, clean, and dry because poor connections can heat up, cause bad welds, produce dangerous arcs and sparking, and even melt.

______c. Keep work area, equipment, and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

______d. Dip a gun in water to cool it only in emergencies.

Written Test

______e. When working with welding machines set up for multiple operation, be very careful not to touch hot parts of the gun because open-circuit voltages from two machines are increased and can cause a severe shock.

______f. Disconnect and lock out all electric power sources before doing any work on electrical equipment.

______g. Keep welding cables as close to the work area as possible and do not connect cables to building framework because current can be directed through lifting chains and cables and weaken them.

______h. When working in high places, carefully examine work area for electrical hazards because a shock in such conditions could cause a fall and severe injury.

8. Select true statement about guidelines for duty cycle safety. Place an "X" beside each true statement.

Note: For a statement to be true, all parts of the statement must be true.

______a. Duty cycle is a performance reference used to avoid using the wrong welding cable.

______b. Duty cycle is based on a one hour period and the length of time during that period that a machine can be safely operated.

______c. Since duty cycle is rated at the maximum output of a welding machine, the lower the percentage, the more attention is required to time spent actually welding.

______d. Use the NEMA classification on the welding machine as a guideline to safe operation

(1) Class I — Rated to deliver output at duty cycles of 60, 80, or 100%
(2) Class II — Rated to deliver output at duty cycles of 30, 40, or 50%
(3) Class III — Rated to deliver output at duty cycles of 20%

Written Test

9. Solve problems about rules for handling cables and gas and coolant hoses. Circle the number of the item that best solves each of the following problems.

   a. You notice another worker dragging a cable through dirt and trying to pull it over a tool rack. The solution to the problem should be:

      (1) Carry the cable through the dirt and place it safely over the tool rack because cables should not be dragged through oil or dirt, and should not be pulled over obstructions.
      (2) Be sensible and move the welding machine to avoid having to manipulate the cable.
      (3) Make sure the dirt is dry and that the cable is moving freely over the obstruction.

   b. You notice another worker cleaning a cable with a rag that has been wet with gasoline. The solution to the problem should be:

      (1) Be sure to clean the gasoline off with a dry rag after the cable is cleaned.
      (2) Be sure the rag is only slightly wet with gasoline.
      (3) Use a safe cleaning solvent because oily rags or gasoline-soaked rags should never be used to clean cables.

   c. You notice a fellow worker has a welding cable draped over a gas cylinder. The solution to the problem should be:

      (1) Make sure the welding current is off.
      (2) Move the cable to a safe position because a welding cable should never be draped over a gas cylinder.
      (3) Disconnect the cable completely so there will be no risk involved.

10. Complete statements about rules for handling hollow castings or containers. Circle the material that best completes each statement.

    a. Hollow castings or containers should be (**thoroughly washed**) (**vented**) before any heating, cutting, or welding activity.

    b. Tanks, drums, and sealed containers should not be heated, cut, or welded until they have been carefully (**aired out**) (**purged**) of any toxic or flammable materials.

Written Test

11. Select true statements about hazards associated with arc burn. Place an "X" beside each true statement.

    _______a. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.

    _______b. Radiation from a welding arc is strong enough to sunburn or sometimes blister bare skin if the exposure is intense or for an extended period, so arms, legs, and torso should be covered with durable flame-resistant clothing.

    _______c. Work stations and work areas should be shielded to prevent an arc flash from injuring nearby workers or visitors.

12. Complete statements about types of welding helmets and their characteristics. Circle the material that best completes each of the following statements.

    a. Stationary filter lens — This type hood has a (**flexible**) (**fixed**) lens housing with the shaded lens held in by a spring retainer from where a lens can be slipped out and replaced as welding requires

    b. Flip-front filter lens — This type hood has a lens housing with a front side that can be flipped up so that it leaves a (**plastic**) (**dark**) lens that permits the hood to be worn while cleaning

13. Complete statements about guidelines for selecting a safe lens shade for GMAW. Circle the material that best completes each of the following statements.

    a. Safe lens selection for GMAW depends on electrode size, which in turn dictates (**duty cycle**) (**amperage or current**) setting.

    b. The rule of thumb for GMAW lens selection is that the higher the amperage, the (**higher**) (**lower**) the lens shade number required.

    c. Operator comfort is also an important part of lens shade selection, and some welders can operate safely with a minimum protective shade while others may require a (**lighter**) (**darker**) shade for comfort and safety.

    d. In all cases, never use the GMAW process with anything less than a (**#7**) (**#9**) lens shade.

    e. When you remove your welding hood and see white spots or blotches as after images, switch to a shade at least (**one number darker**) (**one number lighter**), or check the seal on your lens.

Written Test

14. Select true statements about protective clothing required for GMAW. Place an "X" beside each true statement.

______a. Welder's cap—Has a flexible bill that can be slipped around to cover either ear and keep sparks or metal spatter out of the ear opening

______b. Shirts and pants—Heavy, long sleeve shirts with pockets that have flaps, cuffless pants not frayed at the bottom, and avoid clothing made of synthetic materials

______c. Leather jackets and aprons—Should be worn for additional protection, especially when welding out of position or in confined areas where flying sparks present an increased hazard

______d. Boots—Should be made of heavy leather with uppers that reach above the ankle to help prevent burns from sparks and spatter, and steel-toed boots are not required because they are too heavy and cause fatigue

______e. Gloves—Heavy leather gloves with gauntlets are required for all welding and cutting activities

______f. Safety glasses—Should have nonmetal frames, impact-resistant lenses with side shields to protect from flying objects, and should be worn only when preparing metal for welding

______g. Face shield—Should be a clear-plastic type to provide good visibility when grinding or sanding base metals for GMAW

15. Complete statements about environmental safety requirements. Circle the material that best completes each of the following statements.

a. Ventilation—Many welding activities produce (**toxic**) (**irritating**) fumes and vapors that are hazardous to breathe, and every work station should be equipped with a ventilation or exhaust system capable of safely removing dangerous and irritation smoke and contaminants.

b. Respirators—In confined areas where the hazard of toxic fumes is increased, a welder should wear an air-supplied respirator or a self-contained breathing apparatus, not a filter-type mask that cannot compensate for (**oxygen displacement**) (**the presence of toxic fumes**).

c. Noise—This is a workplace hazard frequently overlooked, but ear plugs or muffler-type ear protectors should be worn when the work area subjects a welder to high noise levels, especially high noise levels (**that are continuous**) (**close by**).

d. Lighting—Lighting in a work area or at a work station should be bright enough to provide good visibility free of glare because poorly lit work areas contribute to eye fatigue, (**absenteeism, and poor health**) (**irritation, and poor work**).

Written Test

16. Select true statements concerning safety guidelines for working with electrode wire. Place an "X" beside each true statement.

______a. Always wear safety glasses when working with electrode wire because a loose end could spring up and severely injure an eye.

______b. Make sure you have the correct spool or coil before loading and cutting tie wires.

______c. Hold the free end of electrode wire firmly to avoid backlash during the reloading procedure because failure to do so could ruin an entire spool or coil.

______d. Position coils close to the reel before lifting, and lift with your legs, not your back, because standard coils weigh 50-60 pounds.

______e. Never look into a gun while you are feeding wire through it, and never point the gun at anyone else.

______f. Check feeding by placing your finger or hand over the contact tip.

***Permission to duplicate this test is granted.**

GMAW Orientation and Safety
Unit 1

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Assignment Sheet 1—Solve Problems About GMAW Safety Rating _____

Comments: ____

____

Written Test Scores

Pretest _____ Posttest _____ Other _____

Other ____

____

Teacher Signature ______________________________ Date __________

Student Signature ______________________________ Date __________

*Permission to duplicate this form is granted.

GMAW Orientation and Safety
Unit 1

Teacher Supplement 1—A Brief History of GMAW

Gas metal arc welding has answered special needs in industry. The GMAW process provides greater deposition rates and faster welding speeds. Use the following materials to provide students with items of historical interest in one of the industry's most efficient and popular welding processes.

1. After World War II, aluminum and magnesium were used more and more in industry because of their strength-to-weight ratios and their better resistance to corrosion, but thicknesses above ¼" were difficult to weld with the TIG process because of problems with heat transfer.

2. The need for a welding process that could control heat in a small area led to the first patent for welding with consumable electrode welding equipment, and this was issued in 1948.

3. Hand in hand with the development of the GMAW process came the development of an iron powder covering for electrodes which provided a greater deposition rate and faster welding speeds

4. Other developments led to the use of gas mixtures to provide a more stable welding arc instead of using pure argon or helium as a shielding gas.

5. As the use of the GMAW process expanded, the high cost of argon and helium led to the use of CO_2 (carbon dioxide) as a shielding gas, an idea that had been patented by John C. Lincoln back in 1918.

6. The use of low-cost CO_2 as a shielding gas led to the expansion of the GMAW process into automotive shops and other industries where less critical welding applications are demanded

   Note: Although "MIG" is frequently used to mean the same thing as GMAW, it is not appropriate in some cases because the "I" in MIG means that in inert gas is used, but since CO_2 is a reactive gas, the use of MIG to define the process is not technically correct.

GMAW Orientation and Safety
Unit 1

Information Sheet

1. **Terms and definitions**

   a. **Automatic** — A GMAW process in which the welding current is continuous in a programmed application; the workpieces travels under a welding head or the welding head travels along the workpiece

   b. **Consumable** — That which can be used up, a way of defining electrode wires used in GMAW

   c. **Contaminants** — Elements in air, impurities in shielding gases, or chemical reactions between base metals and electrodes

   d. **Deposition** — The weight of filler metal placed onto or into a weld in a given period of time

   e. **Gas Metal Arc Welding (GMAW)** — An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding comes entirely from an externally supplied gas

   f. **Inert** — An element that has no active properties

   g. **Metal Inert Gas (MIG)** — A nonstandard term still used in reference to GMAW

   h. **NEMA** — National Electrical Manufacturer's Association

   i. **Oxygen displacement** — A reduction of oxygen in the breathing zone around a welding activity caused by any arc or flame

   j. **Reactive** — An element or gas that has properties which will actively combine with other elements present in a base metal or a filler electrode at high temperature

   k. **Semi-automatic** — A GMAW process in which the welding current is completed as an operator squeezes a gun trigger

   l. **Shielding gases** — Inert gases such as argon or helium, or reactive gases such as CO_2, which are directed under pressure into a weld zone to protect it from atmospheric contamination

   m. **Toxic hazards** — Poisonous gases, fumes, and vapors produced by chemical reactions in certain welding processes

Information Sheet

2. **Advantages of the GMAW process**

   a. Beginners can be more quickly trained to weld with the GMAW process than with any other welding process.

   b. Because GMAW better controls heat in the weld zone, it reduces distortion in base metals.

   c. Because the GMAW arc is always visible to the operator, better welds are possible.

   d. GMAW gives a high deposition efficiency with up to 98% of the welding wire deposited in the joint.

   e. GMAW is adaptable to both ferrous and nonferrous metals in all thicknesses through modification of electrode wire and shielding gas selections.

   f. GMAW is adaptable to either automatic or semi-automatic operation.

   g. GMAW reduces welding costs because it usually requires no cleanup.

3. **Limitations of the GMAW process**

   a. GMAW will not function in a windy environment.

   b. GMAW requires careful setting of electrical components.

   c. GMAW equipment is not as portable as equipment for other welding processes.

4. **Principles of GMAW**

   a. The GMAW process usually operates on DCEP (DCRP).

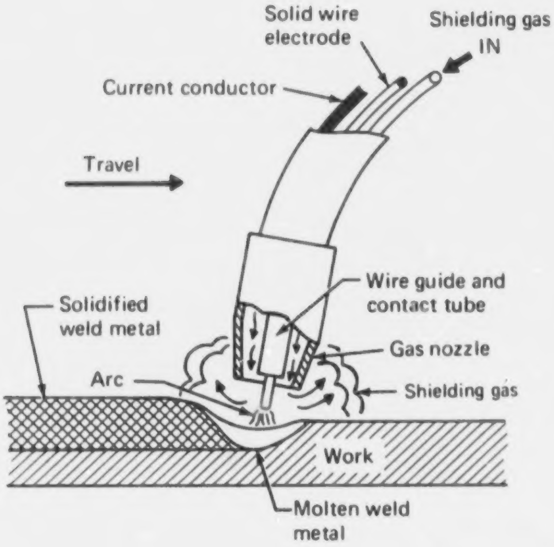
   b. The GMAW process is controlled by arc amperage and voltage.

   c. Arc amperage in the weld zone is controlled by feeding a bare electrode wire through a wire feeder and cable assembly at a preset feed speed which is calibrated in inches-per-minute.

   d. Voltage is controlled by a dial on the welding machine.

Information Sheet

e. As the arc is struck, a shielding gas is forced around the electrode wire and the weld zone to stabilize the arc and protect the molten filler metal and base metal from contaminants.


Solid wire electrode
Shielding gas IN
Current conductor
Travel
Wire guide and contact tube
Solidified weld metal
Gas nozzle
Arc
Shielding gas
Work
Molten weld metal

Courtesy Lincoln Electric Company

5. GMAW applications

a. GMAW is widely used to join all major commercial steels, including carbon, alloy, and stainless, and in production manufacturing of sheet and plate products.

b. GMAW is widely used to join all major nonferrous metals, especially aluminum, magnesium, and copper.

c. GMAW is often used where fit-up is not critical because the high deposition rate can bridge gaps that other processes cannot handle.

d. GMAW is widely used where quick electrical adjustments can be made to compensate for different welding applications without changing electrode wire.

6. Benefits from learning GMAW

a. Working with GMAW is a good way for a student to learn the concept of a consumable electrode, and shielding gases and their uses.

b. The GMAW process introduces students to electrical concepts and electrical controls that other welding processes do not require.

Information Sheet

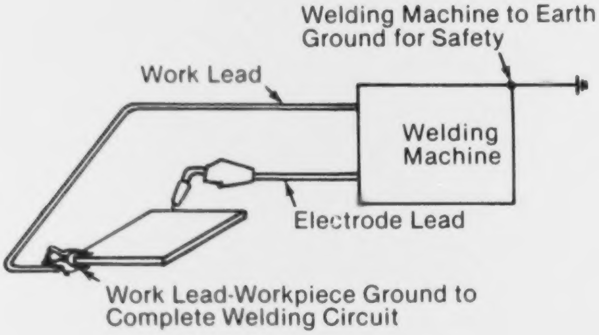
c. GMAW gives students a better idea of what "operator control" really means in a welding process.

d. As students work with GMAW, they will experience better visibility of the arc, electrode, and total weld zone than with other processes.

e. Learning GMAW provides an profitable part-time employment and additional job-getting skill for industry.

7. **Electrical safety requirements for GMAW**

a. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead to workpiece ground that completes the welding circuit.


Welding Machine to Earth Ground for Safety
Work Lead
Welding Machine
Electrode Lead
Work Lead-Workpiece Ground to Complete Welding Circuit

b. Keep electrical connections tight, clean, and dry because poor connections can heat up, cause bad welds, product dangerous arcs and sparking, and even melt.

c. Keep work area, equipment, and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

d. Never dip a gun in water to cool it.

e. When working with welding machines set up for multiple operation, be very careful not to touch hot parts of the gun because open-circuit voltages from two machines are increased and can cause a severe shock.

f. Disconnect and lock out all electric power sources before doing any work on electrical equipment.

g. Keep welding cables as close to the work area as possible and do not connect cables to building framework because current can be directed through lifting chains and cables and weaken them.

h. When working in high places, carefully examine work area for electrical hazards because a shock in such conditions could cause a fall and severe injury.

Information Sheet

8. Guidelines for duty cycle safety

a. Duty cycle is a performance reference used to avoid overheating and perhaps ruining a welding machine.

b. Duty cycle is based on a ten-minute period and the length of time during that period that a machine can be safely operated.

Example: A machine with 20% duty cycle could safely operate 2 minutes out of each 10 minute period.

c. Since duty cycle is rated at the maximum output of a welding machine, the lower the percentage, the more attention is required to time spent actually welding.

d. Use the NEMA classification on the welding machine as a guideline to safe operation:

  (1) Class I — Rated to deliver output at duty cycles of 60, 80, or 100%

  (2) Class II — Rated to deliver output at duty cycles of 30, 40, or 50%

  (3) Class III — Rated to deliver output at duty cycles of 20%

9. Rules for handling cables and gas and coolant hoses

a. Never drag cables or hoses through dirt or oil, and never pull on a cable to force it over an obstruction.

b. Use only clean dry rags to clean cables and hoses, and never use gasoline or an oily rag for the job.

c. When not in use, keep cables and hoses coiled free of kinks and properly stored.

d. Never drape a welding cable over any type of gas cylinder, and NEVER strike an arc on a gas cylinder.

e. Never interchange gas and water hoses.

10. Rules for handling hollow castings or containers

a. Hollow castings or containers should be vented before any heating, cutting, or welding activity.

b. Tanks, drums, and sealed containers should not be heated, cut, or welded until they have been carefully purged of any toxic or flammable materials.

Information Sheet

11. Hazards associated with arc rays

a. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.

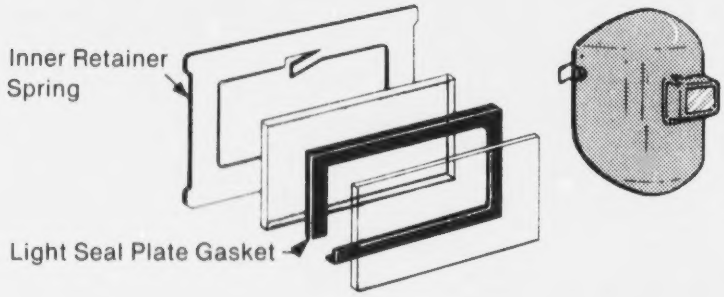
Note: A welding hood or helmet protects the head from flying sparks, but the shaded lens is also required for eye protection.

b. Radiation from a welding arc is strong enough to sunburn or sometimes blister bare skin if the exposure is intense or for an extended period, so arms, legs, and torso should be covered with durable flame-resistant clothing.

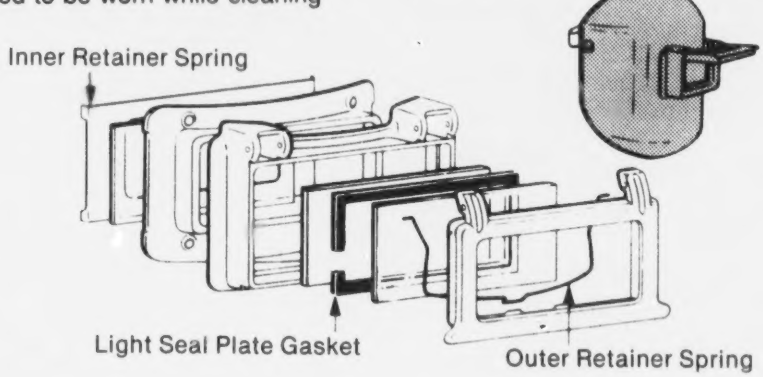
c. Work stations and work areas should be shielded to prevent an arc flash from injuring nearby workers or visitors.

12. Types of welding helmets and their characteristics

a. Stationary filter lens — This type hood has a fixed lens housing with the shaded lens held in by a spring retainer from where a lens can be slipped out and replaced as welding requires



b. Flip-front filter lens — This type hood has a lens housing with a front side that can be flipped up so that it leaves a clear-glass or plastic lens that permits the hood to be worn while cleaning



Information Sheet

13. Guidelines for selecting a safe lens shade for GMAW

a. Safe lens selection for GMAW depends on electrode size, which in turn dictates amperage or current setting.

b. The rule of thumb for GMAW lens selection is that the higher the amperage, the higher the lens shade number required.

c. Operator comfort is also an important part of lens shade selection, and some welders can operate safely with a minimum protective shade while others may require a darker shade for comfort and safety.

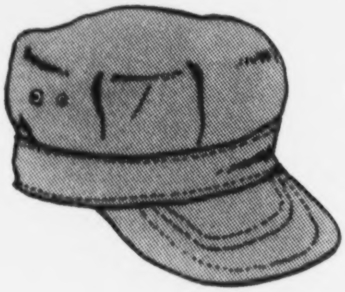
Amperage	Minimum Protective Shade	Suggested Comfort Shade
Less than 60	7	—
60-160	10	11
160-250	10	12
250-500	10	14

d. In all cases, never use the GMAW process with anything less than a #7 lens shade.

e. When you remove your welding hood and see white spots or blotches as after images, switch to a shade at least one number darker, or check the seal on your lens.

14. Protective clothing required for GMAW welding

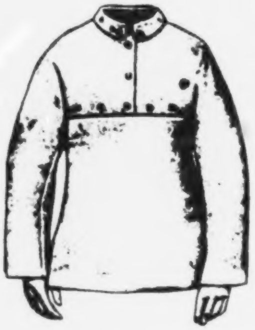
a. Welder's cap—Has a flexible bill that can be slipped around to cover either ear and keep sparks or metal spatter out of the ear opening

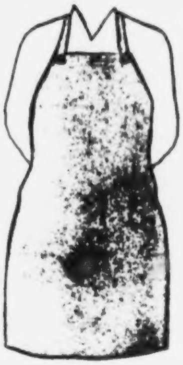


b. Shirts and pants—Heavy, long sleeve shirts with pockets that have flaps, cuffless pants not frayed at the bottom, and avoid clothing made of synthetic materials

Information Sheet

c. Leather jackets and aprons—Should be worn for additional protection, especially when welding out of position or in confined areas where flying sparks present an increased hazard

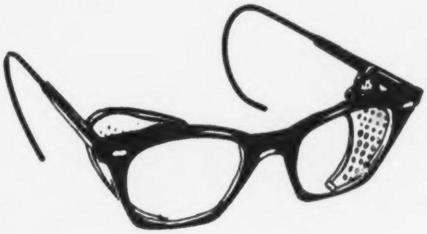




d. Boots—Should be made of heavy leather with uppers that reach above the ankle to help prevent burns from sparks and spatter, and although steel-toed boots are not required, they are highly recommended

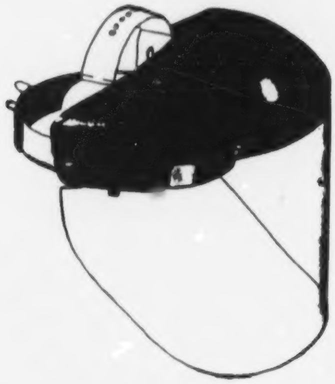
e. Gloves—Heavy leather gloves with gauntlets are required for all welding and cutting activities

f. Safety glasses—Should have nonmetal frames, impact-resistant lenses with side shields to protect from flying objects, and should be worn at all times in the shop area



Information Sheet

g. Face shield—Should be a clear-plastic type to provide good visibility when grinding or sanding base metals for GMAW



15. **Environmental safety requirements**

a. Ventilation—Many welding activities produce toxic fumes and vapors that are hazardous to breathe, and every work station should be equipped with a ventilation or exhaust system capable of safely removing dangerous and irritation smoke and contaminants.

Caution: Always position your head to the side of rising fumes.

b. Respirators—In confined areas where the hazard of toxic fumes is increased, a welder should wear an air-supplied respirator or a self-contained breathing apparatus, not a filter-type mask that cannot compensate for oxygen displacement.

Caution: Argon is much heavier than air and will quickly displace oxygen, so be especially careful using the GMAW process in confined areas, even though they appear to have adequate ventilation.

c. Noise—This is a workplace hazard frequently overlooked, but ear plugs or muffler-type ear protectors should be worn when the work area subjects a welder to high noise levels, especially high noise levels that are continuous.

d. Lighting—Lighting in a work area or at a work station should be bright enough to provide good visibility free of glare because poorly lit work areas contribute to eye fatigue, irritation, and poor work.

Information Sheet

16. Safety guidelines for working with electrode wire

a. Always wear safety glasses when working with electrode wire because a loose end could spring up and severely injure an eye.

b. Make sure you have the correct spool or coil before loading and cutting tie wires.

c. Hold the free end of electrode wire firmly to avoid backlash during the reloading procedure because failure to do so could ruin an entire spool or coil.

d. Position coils close to the reel before lifting, and lift with your legs, not your back, because standard coils weigh 50-60 pounds.

e. Never look into a gun while you are feeding wire through it, and never point the gun at anyone else.

f. Never place your finger or hand over the contact tip to see if the wire is feeding properly.

GMAW Orientation and Safety
Unit 1

Assignment Sheet 1—Solve Problems About GMAW Safety

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Recognition of problems	_____
Accuracy of solutions	_____

Directions: Read the following statements carefully, then write a brief statement recommending a specific solution if there is a safety violation presented.

a. A fellow student is attempting to repair a malfunctioning gun while the welding machine is still on. Is there a problem? ______________________________

Solution: ______________________________

____

b. You are working with a welding machine that has a Class III NEMA rating and realize that you have been welding for almost five minutes without stopping. Is there a problem? ______________________________

Solution: ______________________________

____

c. A co-worker is using an oily rag to clean a welding cable. Is there a problem? ____

Solution: ______________________________

____

d. It is hot and you are sweating and decide that it's safe to pull up your sleeves to be a little more comfortable, and you are certain that no sparks will hit you so you feel safe. Is there a problem? ______________________________

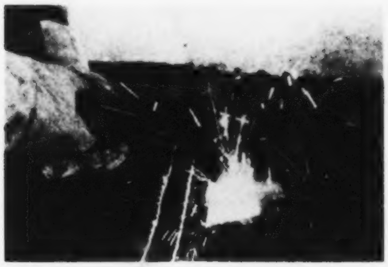
Solution: ______________________________

____

e. You notice a co-worker reloading a coil of electrode wire without wearing safety glasses. Is there a problem? ______________________________

Solution: ______________________________

____



GMAW Equipment, Applications, and Techniques
Unit 2

Objective Sheet

Unit Objective

After completing this unit, the student should be able to set up equipment for gas metal arc welding, and weld lap joints, V-groove joints, and T-joints on ferrous and nonferrous metals in all positions. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to GMAW equipment, applications, and techniques with their correct definitions.
2. Complete statements about characteristics of short-circuit transfer.
3. Complete statements about characteristics of globular transfer.
4. Complete statements about characteristics of spray transfer.
5. Match GMAW machine controls with their functions.
6. Match GMAW electrical controls with their functions.
7. Match wire feeder controls with their functions.
8. Solve problems about roll adjustment requirements for wire feeders.
9. Select true statements about preventive maintenance requirements for wire feeders.
10. Select true statements about AWS classifications for electrode wires.
11. Match short-circuit electrode wires with their characteristics.
12. Solve problems about rules of thumb for GMAW electrode wire selection.

Objective Sheet

13. Select true statements about guidelines for storing spools and coils of electrode wire.

14. Complete statements about GMAW guns and their characteristics.

15. Match parts of a GMAW gun tip with their functions.

16. Complete statements about steps in assembling contact tips, gas diffusers, nozzles, and insulators.

17. Solve problems about maintenance requirements for GMAW guns.

18. Select true statements about electrode extension and its function in GMAW.

19. Complete statements about GMAW shielding gases and their applications.

20. Differentiate between GMAW welding techniques and their characteristics.

21. Solve problems about techniques for properly ending a GMAW weld.

22. Select true statements about techniques for position welding with GMAW.

23. Complete statements about conditions that require special attention with GMAW.

24. Complete a chart of possible causes and corrective actions for undercutting.

25. Complete a chart of possible causes and corrective actions for porosity.

26. Complete a chart of possible causes and corrective actions for incomplete fusion.

27. Complete a chart of possible causes and corrective actions for incomplete joint penetration.

28. Complete a chart of possible causes and corrective actions for excessive melt-through.

29. Complete statements about flow meters and their use in GMAW.

30. Select true statements about flow rates for GMAW shielding gases.

31. Solve problems about guidelines for troubleshooting GMAW problems.

32. Set up wire on a spool-type GMAW wire feeder. (Job Sheet 1)

33. Set up a flow meter and regulator for a GMAW shielding gas. (Job Sheet 2)

Objective Sheet

34. Set up GMAW equipment for short-circuit transfer on mild steel. (Job Sheet 3)

35. Prepare mild steel for GMAW. (Job Sheet 4)

36. Use short-circuit transfer to lay stringer beads on mild steel in the flat position. (Job Sheet 5)

37. Use short-circuit transfer to build a pad on mild steel in the flat position. (Job Sheet 6)

38. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position. (Job Sheet 7)

39. Break test a single-pass lap joint. (Job Sheet 8)

40. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position. (Job Sheet 9)

41. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the flat position. (Job Sheet 10)

42. Bend test a welded V-groove butt joint. (Job Sheet 11)

43. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position. (Job Sheet 12)

44. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position. (Job Sheet 13)

45. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the horizontal position. (Job Sheet 14)

46. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the vertical position. (Job Sheet 15)

47. Use short-circuit transfer to weld to specifications a fillet weld T-Joint on mild steel in the vertical position. (Job Sheet 16)

48. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the vertical position. (Job Sheet 17)

49. Use short-circuit transfer to weld to specifications a fillet weld lap joint on mild steel in the overhead position. (Job Sheet 18)

50. Use short-circuit transfer to weld to specifications a fillet weld T-joint on mild steel in the overhead position. (Job Sheet 19)

Objective Sheet

51. Use short-circuit transfer to weld to specifications a V-groove butt joint on mild steel in the overhead position. (Job Sheet 20)

52. Set up GMAW equipment for spray transfer with mild steel. (Job Sheet 21)

53. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the flat position. (Job Sheet 22)

54. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the flat position. (Job Sheet 23)

55. Use spray transfer to weld to specifications a fillet weld lap joint on mild steel in the horizontal position. (Job Sheet 24)

56. Use spray transfer to weld to specifications a fillet weld T-joint on mild steel in the horizontal position. (Job Sheet 25)

57. Set up GMAW equipment for spray transfer on aluminum. (Job Sheet 26)

58. Prepare aluminum for GMAW. (Job Sheet 27)

59. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the flat position. (Job Sheet 28)

60. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the flat position. (Job Sheet 29)

61. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the horizontal position. (Job Sheet 30)

62. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the horizontal position. (Job Sheet 31)

63. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical up position. (Job Sheet 32)

64. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical up position. (Job Sheet 33)

65. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the vertical down position. (Job Sheet 34)

66. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the vertical down position. (Job Sheet 35)

67. Use spray transfer to weld to specifications a fillet weld lap joint on aluminum in the overhead position. (Job Sheet 36)

68. Use spray transfer to weld to specifications a fillet weld T-joint on aluminum in the overhead position. (Job Sheet 37)

GMAW Equipment, Applications, and Techniques
Unit 2

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review teaching suggestions section that follows. Plan for classroom activities.

3. Plan for enrichment of exceptional students as well as accommodation of special needs students.

4. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.

5. Develop teaching plan. Adjust for different learning styles.

6. Make copies of Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.

8. Discuss unit and specific objectives.

9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

10. Discuss the job sheets. Review criteria for evaluation of these activities.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for students evaluation.

12. Make copies of written test. Add or modify test questions as needed.

13. Give written test.

14. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

15. Reteach and retest as required.

Suggested Activities

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Discuss area shops or manufacturers who use gas metal arc welding in their production. Invite owners or supervisors to talk to the class about job opportunities for welders with GMAW skills. Skill area: **personal and career development**.
2. Use the early objectives to impress upon students the importance of electrical controls in GMAW. Stress relationships between control settings and electrode extension. Note that electrode extension is the new AWS reference for what use to be called electrode stickout. Skill area: **learning to learn**.
3. In Objectives 20 and 21, stress the importance of welding technique. Inform students that part of their job sheet evaluations will rate welding technique as well as crater and fill technique for properly ending a GMAW weld. Skill area: **learning to learn**.
4. Reinforce Objective 28 by staging problems for students to troubleshoot. Skill area: **learning to learn**.
5. There are many job sheets in this unit, and they have been arranged so that all mild steel job sheets and all aluminum job sheets are grouped together. Group the job sheets to best take advantage of resources in your welding facility. Try to localize instruction so that all students will get training on both mild steel and aluminum projects.

Resources Used in Developing This Unit

1. Connor, Leonard P., ed. *Welding Handbook Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1987.
2. O'Brien, R. L., ed. *Welding Handbook Eighth Edition, Vol. 2, Welding Processes*. Miami, FL: American Welding Society, 1991.
3. *1988/89 Welding & Fabrication Data Handbook*. Cleveland, OH: Penton Publishing, Inc., 1988.
4. *The Procedure Handbook of Arc Welding, Twelfth Edition*. Cleveland, OH: The Lincoln Electric Company, 1973.
5. *New Lessons in Arc Welding*. Cleveland, OH: The Lincoln Electric Company, 1981.
6. Fortney, Clarence and Mike Gregory. *Gas Metal Arc Welding and Flux-Cored Arc Welding*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

Suggested Activities

7. *Welding Power Handbook*. New York: Union Carbide Corporation, Linde Division, 1973.

8. Althouse, Andrew D., Carl H. Turnquist, and William A. Bowditch. *Modern Welding*. South Holland, IL: The Goodheart-Willcox Co., Inc., 1980.

Suggested Supplemental Resources

1. HOB-10, GMAW Basic, and HOB-11, GMAW Advanced. Videocassette tapes and other formats. Available from:

   Hobart School of Welding Technology
   Trade Square East
   Troy, OH 45373
   513-332-5217

2. ITC-7, Principles and Techniques of MIG, including GMAW safety, equipment, and both plate and pipe welding. Videotapes with students and instructor materials. Available from:

   Industrial Training Corporation
   13515 Dulles Technology Drive
   Herndon, VA 22071-3416
   800-638-3757 or 703-471-1414

3. KEN-3, Gas Metal Arc Training Program. Videotapes with students and instructor materials and GMAW equipment. Available from:

   Ken Cook Education Systems
   12855 West Silver Spring Drive
   P.O. Box 207
   Butler, WI 53007
   800-362-2665

4. MIL-4, Short Circuiting Metal Transfer. Videocassette includes six checkpoints, nine arc studies. Available from:

   Miller Electric Mfg. Co.
   718 South Bound Street
   Appleton, WI 54912
   414-734-9821

Suggested Activities

5. REY, Effect of Arc Variations on Aluminum Welds. 16 mm. film. Available on loan from:

   Reynolds Metals Co.
   Corporate Creative Services
   P.O. Box 27003
   Richmond, VA 23261
   804-281-3928

6. VTR-3, GMAW and GTAW Welding. Videotapes with student and teacher materials. Available from:

   Video Training Resource, Inc.
   7500 West 78th Street
   Edina, NM 55435-2889
   800-828-8190 or 612-944-8190

Instructions For Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

GMAW Equipment, Applications, and Techniques
Unit 2

Answers to Written Test

1. a. 4 f. 10
   b. 6 g. 7
   c. 8 h. 2
   d. 1 i. 9
   e. 3 j. 5

2. a. Low, small
   b. Thin
   c. No metal
   d. Argon

3. a. Greater
   b. Only slightly
   c. Short circuiting
   d. Gravity alone
   e. Mild steels

4. a. DCEP
   b. Gravity
   c. Smaller
   d. Argon-rich

5. a. 3 d. 1
   b. 5 e. 4
   c. 6 f. 2

6. a. 4 f. 5
   b. 6 g. 1
   c. 8 h. 3
   d. 9 i. 7
   e. 2

7. a. 5 e. 6
   b. 3 f. 2
   c. 8 g. 7
   d. 1 h. 4

8. a. 2
   b. 2

9. b, d

Answers to Written Test

10. a, c, e

11. a. 5
    b. 2
    c. 8
    d. 6
    e. 4
    f. 7
    g. 1
    h. 3

12. a. 3
    b. 2
    c. 1

13. a, c

14. a. Short-circuit
    b. Spray
    c. Wire feed unit
    d. A spool or reel
    e. Aluminum

15. a. 4
    b. 3
    c. 1
    d. 2

16. a. An adjustable wrench
    b. Pliers
    c. Hand tighten
    d. Electrode extension

17. a. 1
    b. 3
    c. 2

18. a, d, e

19. a. Nonferrous
    b. Argon
    c. Deoxidizing agents
    d. Both mild and stainless steels

20. a. F
    b. B
    c. F
    d. B

Answers to Written Test

21. a. 3
    b. 2
    c. 1

22. a, b, c, d, e, f, g

23. a. More
    b. Aluminum
    c. Reduced
    d. Hydrogen
    e. Contaminants
    f. Corrected

Note: Student answers for questions 24 through 28 should approximate those given.

24. a. Reduce travel speed.
    b. Reduce voltage.
    c. Reduce wire feed speed.
    d. Change gun angle so that arc force can aid in metal placement.

25. a. Increase gas flow to displace air from the weld zone, or decrease gas flow to avoid turbulence and air entrapment in the weld zone.
    b. Use welding grade shielding gases.
    c. Use only clean, dry electrode wire.
    d. Perform better preweld cleaning. Use more highly deoxidizing electrode wire.
    e. Reduce voltage.
    f. Reduce electrode extension.

26. a. Clean weld zone surface free of mill scale before welding.
    b. Increase wire feed speed and arc voltage, and reduce electrode extension.
    c. Minimize weaving to produce a more controllable weld puddle. Increase travel speed.
    d. Keep electrode directed at the leading edge of the puddle. When weaving, dwell momentarily on the side walls of grooves. Provide improved access to roots of joints.
    e. Use angle groove large enough to allow access to bottom of the groove and sidewalls with proper extension, or use "U" or "J" groove.

27. a. Provide proper access to the bottom of the groove while maintaining proper electrode extension. Reduce excessively large root face. Increase the root gap in butt joints, and increase the depth of back gouge.
    b. Maintain electrode angle normal to work surface to achieve maximum penetration. Keep arc on leading edge of puddle.
    c. Increase the wire feed speed.

Answers to Written Test

28. a. Reduce wire feed speed and voltage. Increase travel speed.
    b. Reduce root opening. Increase root face dimensions.

29. a. Low
    b. Hour
    c. Vertical
    d. Uniform
    e. A mixer

30. c

31. a. 2
    b. 3

GMAW Equipment, Applications, and Techniques
Unit 2

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

______a. The distance between the end of the contact tube and the end of the electrode

______b. A GMAW application in which average currents slightly higher than those used with short-circuit transfer are used to form a droplet that goes onto a base metal as a result of short-circuiting or gravity

______c. The rate of rise of current as opposed to the final amount of current available; used in short-circuit transfer to increase or decrease the number of short-circuit metal transfers per second

______d. A GMAW application in which low currents, low voltages, and small diameter wires are used to weld in all positions on thin to heavy metals

______e. The slant of the volts versus amp curve, or the volts change per 100 amps

______f. A power supply control that regulates the amount of pinch force available on welding wire and controls spatter in short-circuit transfer

______g. A GMAW application in which high currents, high voltages, and larger diameter wires are used to weld thicker metals mostly in the flat and horizontal positions

1. Short-circuit transfer
2. Travel speed
3. Slope
4. Electrode extension
5. Work angle
6. Globular transfer
7. Spray transfer
8. Inductance
9. Travel angle
10. Slope control

Written Test

______h. The linear rate at which the arc is moved along the weld joint

______i. The relationship of the electrode axis with respect to the direction of travel

______j. The angle between the electrode axis and the adjacent work surface

2. Complete statements about characteristics of short-circuit transfer. Circle the material that best completes each of the following statements.

   a. Short-circuit transfer with GMAW is accomplished with a (**high**) (**low**) range of welding currents and (**small**) (**large**) diameter wires.

   b. The small, fast-freezing weld pool created with short-circuit transfer makes it suited for joining (**thin**) (**thick**) sections, for out-of-position welding, and for bridging large root openings.

   c. In short-circuit transfer, (**no metal**) (**metal**) is transferred across the arc gap, and the open circuit voltage of the power source must be so low that the drop of molten metal at the wire tip cannot transfer until it touches the base metal.

   d. CO_2 is used as a shielding gas with short-circuit transfer because it promotes deep penetration, but mixtures of CO_2 and (**argon**) (**helium**) are used to control spatter.

3. Complete statements about characteristics of globular transfer. Circle the material that best completes each of the following statements.

   a. Globular transfer with GMAW is characterized by a drop size with a diameter (**smaller**) (**greater**) than that of the electrode.

   b. Globular transfer is accomplished with currents (**only slightly**) (**much**) higher than those used with short-circuit transfer.

   c. One type of globular transfer occurs when the molten drop grows until it detaches by (**short-circuiting**) (**spray transfer**).

   d. Another type of globular transfer occurs when (**gravity alone**) (**arc force**) causes the molten drop to fall onto the weld pool.

   e. CO_2 is commonly used for globular transfer, especially with (**mild steels**) (**aluminum**).

Written Test

4. Complete statements about characteristics of spray transfer. Circle the material that best completes each of the following statements.

   a. Spray transfer with GMAW is accomplished with the use of direct current and a positive electrode (**DCEP**) (**DCEN**).

   b. The current must reach levels above the "transition current" so that a highly directed stream of individual drops are accelerated by arc forces to velocities which overcome the effects of (**gravity**) (**arc blow**).

   c. Because the individual drops are equal to or (**smaller**) (**larger**) than the diameter of the electrode, and are nearly constantly sprayed through the arc plasma, spatter is virtually eliminated.

   d. An (**argon-rich**) (**CO_2-rich**) shielding gas is used to produce the stable spray in spray transfer.

5. Match GMAW machine controls with their functions. Place the number of the control in the blank beside the appropriate definition.

______a. A rectifier-type DC welding machine which controls voltage used in the basic GMAW processes

______b. A roller device used to vary and control the speed at which wire is fed to the welding arc in relation to amperage and wire feed speed

______c. Cable transports power to trigger-operated gun through which the wire, shielding gas, and coolant pass

______d. Trigger-operated on-off device through which wire, shielding gas, and coolant are controlled at the weld zone

______e. Used to reduce high-pressure cylinder gas to low pressure gas so its flow rate can be controlled to the welding gun as measured in CFH (cubic feet per hour)

______f. An on-off switch or valve that activates coolant flow in water-cooled GMAW systems

1. Gun
2. Coolant solenoid
3. Power supply
4. Flowmeter regulator
5. Wire feeder
6. Gun and cable assembly

Written Test

6. Match GMAW electrical controls with their functions. Place the number of the control in the blank beside the appropriate definition.

______a. Used to start or stop the electrical power to a machine

______b. Used to control wide-range voltage selection such as 12-28 volts for low range and 20-35 volts for high range

______c. Used to fine tune the voltage selection within the wide-range setting

______d. Used to calibrate and check voltage adjustments

______e. Used to calibrate and check amperage adjustments

______f. Used to add or decrease the rate of resistance change in a welding machine for pinch control which minimizes spatter

______g. Used to change polarity from DCEP (DCRP) to DCEN (DCSP) so meters for amps and volts can be properly read

______h. Used to complete circuit through wire feed and function as an on-off device for wire feed

______i. Used to control arc-on time in short-circuit welding to control puddle fluidity and produce a flatter, smoother weld bead

1. Polarity switch
2. Power supply ammeter
3. Contactor
4. On-off switch
5. Slope
6. Voltage range selector
7. Inductance
8. Fine voltage control
9. Power supply voltmeter

Written Test

7. Match wire feeder controls with their functions. Place the number of the control in the blank beside the appropriate definition.

_______a. Controls power input into wire feed mechanism

_______b. Functions as a dual control to regulate wire feed rate in inches-per-minute in relation to amperage

_______c. Increases or decreases burn back on electrode extension

_______d. An on-off device that routes current through a timer which provides a specific time for each trigger activation regardless of how long or briefly the trigger is held

_______e. A device to permit purging of a shielding gas through the gun without having wire feed at the same time

_______f. Used to advance wire for setting up purposes and does not activate other components

_______g. A control that makes voltage adjustment possible in situations where welding activity is far enough away from the welding machine to make it impractical to stop welding in order to make adjustments at the machine

_______h. A handy device that permits excess wire spooled off during loading to be rewound and used, as opposed to wasted

1. Spot weld function
2. Wire-inch switch
3. Wire feed control
4. Reverse control
5. On-off switch
6. Purge
7. Remote unit
8. Contactor dropout

Written Test

8. Solve problems about roll adjustment requirements for wire feeders. Circle the number of the material that best solves each of the following problems.

   a. At a GMAW operation, you notice that the electrode wire looks like it has been shaved. The solution to the problem would probably be:

      (1) Replace the wire roll; it's probably bad.
      (2) Loosen the tension on the wire feed roll.
      (3) Let the wire feed for awhile; it will correct its own problem.

   b. At a GMAW operation, you notice small flakes of wire around the feed rolls, but the wire seems to be feeding okay. The solution to the problem would probably be:

      (1) There is no problem because the wire is feeding okay.
      (2) Loosen the tension on the wire feed roll and clean up the metal flakes because they could pose an electrical hazard.
      (3) Loosen the tension on the wire feed roll and check the size of the wire feed rollers.

9. Select true statements about preventive maintenance requirements for wire feeders. Place an "X" beside each true statement.

______a. Feed rolls should be checked and cleaned weekly.

______b. All electrical connections into and out of the feeder should be checked daily and tightened as required.

______c. The drag brake needs to be checked weekly.

______d. All gas hoses and connections should be inspected for leaks before each operation.

10. Select true statements about AWS classifications for electrode wires. Place an "X" beside each statement that is true.

______a. AWS classifications for electrode wire use letter and number designations to identify type of electrode and basic composition.

______b. As in other classifications, the letter E indicates electrode, and when followed by the letter R, it indicates that the filler metal may be used only as an electrode.

______c. Interior numbers indicate minimum tensile strength in multiples of 1,000 psi.

______d. The letter S indicates an electrode with shielding coating.

______e. Final letter-number classifications indicate special chemical compositions of the electrode wire.

Written Test

11. Match short-circuit electrode wires with their characteristics. Place the number of the wire designation in the blank beside the appropriate characteristic.

______a. Designed for welding all grades of carbon steel as well as some low alloy steels

______b. Designed for welding plain carbon and mild steel, and is the least expensive wire for welding steel

______c. Designed for welding mild steel, and is a medium priced wire

______d. Designed for use with CO_2 shielding gas, and can be used on steel with a somewhat rusty or oily surface

______e. Designed for excellent response with CO_2 shielding gas

______f. Similar to the ER-70S-6, but high manganese content promotes wetting and weld appearance

______g. A special electrode classification whose properties are specified by the manufacturer to meet special specifications for electrode filler wires

______h. Designed for certain low alloy and high strength steel

1. ER-70S-G
2. ER-70S-3
3. ER-80S-D2
4. ER-70S-6
5. ER-70S-2
6. ER-70S-5
7. ER-70S-7
8. ER-70S-4

12. Solve problems about rules of thumb for GMAW electrode wire selection. Circle the number of the material that best solves each of the following problems.

a. You have been asked to set up a GMAW project for short-circuit transfer. In the supply room you find a wire spool with .025″ wire and another spool with .060″ wire. Which wire size should be selected?

(1) Neither one. A .045″ wire should be used for short-circuit transfer.
(2) Either one. The electrode extension can easily be adjusted for wire size.
(3) The .025″ wire falls within the guidelines of .020″ to .045″ for short-circuit transfer.

Written Test

b. You have been asked to set up a GMAW project for spray transfer. In the supply room you find a wire spool with .025″ wire and another spool with .060″ wire. Which wire size should be selected?

(1) Neither one. Only a .045″ wire should be used for spray transfer.
(2) The .060″ wire falls within the guidelines of .045″ to .125″ for spray transfer.
(3) Either one. The electrode extension is especially easy to adjust for spray transfer.

c. You have been asked to select a wire size for a project that requires a high deposition rate at the lowest cost in materials for a spray transfer project. In the supply room, you find a spool of .045″ wire, .060″ wire, and .125″ wire. Which wire size should be selected?

(1) Use the .125″ wire unless the project specifies a smaller wire.
(2) Use the .060″ wire and adjust electrode extension for high deposition welding.
(3) Use the .045″ wire because the smaller diameter will permit better penetration and higher deposition.

13. Select true statements about guidelines for storing spools and coils of electrode wire. Place an "X" beside each true statement.

______a. Do not unseal or open spools or coils of electrode wire until they are needed for immediate use.

______b. Store electrode wires in a cool place.

______c. Use spools or coils as soon as possible after opening, and cover or reseal remaining wire prior to storage.

14. Complete statments about types of GMAW guns and their characteristics. Circle the material that best completes each of the following statements.

a. Air cooled—Used in (**short-circuit**) (**spray**) transfer when the welding application requires short distance welds or weld times that are short or intermittent

b. Water cooled—Used in (**short-circuit**) (**spray**) transfer when the welding application requires long distance welds or weld times that are long, especially with larger diameter electrodes

c. Push—A gun that has wire pushed directly into it through drive rollers in the (**gun housing**) (**wire feed unit**)

d. Pull—A gun with a small electric motor that pulls the wire from (**a wire feeder**) (**a spool or reel**) and feeds it through the contact tips to the weld zone

e. Spool—A gun with housing capable of holding a small spool of wire and feeding it through the contact points, and is used primarily in welding (**mild steel**) (**aluminum**) with wire that is too soft to be pushed or pulled a long distance

15. Match parts of a GMAW gun tip with their functions. Place the number of the part in the blank beside the appropriate function.

______a. A copper device used to guide the wire to the weld, and should be selected according to wire size and type of service, standard, heavy duty, or tapered

______b. A copper device that spreads shielding gas out so that it flows evenly over the electrode wire and the weld zone

______c. Insulates the nozzle from the welding current and holds the nozzle in place

______d. Directs and holds shielding gas round the weld zone, and may be standard, tapered for tight places, or heavy duty for continuous welding

1. Nozzle insulator
2. Nozzle
3. Gas diffuser
4. Contact tip

16. Complete statements about steps in assembling contact tips, gas diffusers, nozzles, and insulators. Circle the material that best completes each of the following statements.

a. Screw the gas diffuser into the end of the conductor tube assembly with (**pliers**) (**an adjustable wrench**), and then tighten the Allen screw that holds the wire-feed conduit.

b. Screw the contact tip into the gas diffuser and snug it tight with (**pliers**) (**an adjustable wrench**), but be careful not to damage the contact tip.

c. Screw the nozzle insulator over the diffuser and contact tip and (**hand tighten**) (**tighten with pliers**).

d. Slide the nozzle over the split-spring rings of the insulator and adjust for (**nozzle length**) (**electrode extension**).

Written Test

17. Solve problems about maintenance requirement for GMAW guns. Circle the number of the best solution to each of the following problems.

    a. An air cooled GMAW gun isn't performing exactly right. As you give it a maintenance check, you should:

        (1) Make sure the contact tip is tight and that the contact tip is the right size for the wire being used.
        (2) Check the tension on the feed rollers because this can cause a gun to malfunction.
        (3) Check for leaks in the coolant line.

    b. A water cooled GMAW gun isn't performing properly. As you give it a maintenance check, you should:

        (1) Check the gas diffuser first.
        (2) Check the contact tip.
        (3) Check for hose leaks and a sufficient coolant supply.

    c. A spool gun is not working properly. As you give it a maintenance check, you should:

        (1) Check it out like any other GMAW gun.
        (2) Check the feed roll tension because this is very important on a spool gun.
        (3) Check coolant supply.

18. Select true statements about electrode extension and its function in GMAW. Place an "X" beside each true statement.

    ______a. Electrode extension gives an operator control of slight but critical adjustments of amperage and voltage needed to correct spatter, penetration, and bead width.

    ______b. Too much electrode extension increases amperage and slightly increases voltage; this results in more arc which produces spatter and poor penetration.

    ______c. Too little electrode extension decreases amperage and slightly decreases voltage; this results in less arc which gives no spatter and good penetration, but it produces a narrow bead with overall poor fusion.

    ______d. Electrode extension for short-circuit transfer is ¼″ to ½″.

    ______e. Electrode extension for spray transfer is ½″ to 1″.

Written Test

19. Complete statements about GMAW shielding gases and their applications. Circle the material that best completes each of the following statements.

    a. Argon is the most frequently used shielding gas for welding (**nonferrous**) (**ferrous**) metals because it produces a clean, narrow bead with deep penetration in both short-circuit and spray transfer.

    b. Helium is mixed with argon for some aluminum welding in both short-circuit and spray transfer, but helium does not produce the stable arc provided by (**argon**) (**CO_2**).

    c. CO_2 is used primarily on carbon steels because it is far less expensive than other shielding gases, but because CO_2 can produce an unstable arc and spatter, it requires electrode wires with (**deoxidizing agents**) (**flux**).

    d. Oxygen is used in varying percentages with argon for spray transfer on (**both mild and stainless steels**) (**aluminum**).

20. Differentiate between GMAW welding techniques and their characteristics. Place an "F" beside items that refer to the "forehand" welding technique, and a "B" beside items that refer to the "backhand" welding technique.

    ______a. With this technique, the electrode points in the direction of travel.

    ______b. This technique is mostly used on thinner metals.

    ______c. This technique is mostly used on thicker metals.

    ______d. With this technique, the electrode points opposite the direction of travel.

21. Solve problems about techniques for properly ending a GMAW weld. Circle the number of the material that best solves each of the following problems.

    a. A welder friend tells you that ending a weld is a real problem. To help the friend solve the problem, you could:

       (1) Tell the friend that practice makes perfect.
       (2) Show the friend how the backhand technique is used to end a weld.
       (3) Demonstrate to the friend how to release the gun trigger just as the bead reaches the end of the weld.

    b. A friend who has been experimenting with the proper way to end a weld is still having a problem. To help the friend solve the problem, you could:

       (1) Encourage the friend to keep practicing.
       (2) Show the friend how to hesitate for just a second and hold the gun in place after releasing the trigger.
       (3) Demonstrate the forehand technique to your friend.

Written Test

c. A friend who has been experimenting with properly ending a weld is having some real problems with a weld that starts in a corner. To help the friend solve the problem, you should:

(1) Show your friend the alternate technique of reversing the travel direction before breaking the arc.
(2) Demonstrate to your friend how the backhand technique is made to order for welding out of corners.
(3) Tell your friend to adjust electrode extension and use a forehand welding technique.

22. Select true statements about techniques for position welding with GMAW. Place an "X" beside each true statement.

______a. For single-pass butt joints in the flat position, use a slight back-stepping motion, but for flat position open-root butt joints, use a small weave.

______b. For fill and cover passes in the flat position, weave to desired width.

______c. For fillet welds in the horizontal position, use a circular weave.

______d. For V-groove butt joints in the horizontal position, use a weave to accomplish the desired width.

______e. For both single-pass and multi-pass groove welds, and for fillet welds in the vertical up position, use a weaving technique.

______f. For all welds in the vertical down position, take special care to keep the arc in the leading edge of the puddle so the molten metal will not run around the arc and cause cold lapping.

______g. For both groove and fillet welds in the overhead position, use a weaving technique.

23. Complete statements about conditions that require special attention with GMAW. Circle the material that best completes each of the following statements.

a. Base metal cleanliness is (**more**) (**less**) critical with GMAW than with some other welding processes.

b. Preweld and interpass cleaning are essential for GMAW, and especially for (**aluminum**) (**mild steel**) where chemical cleaning and/or mechanical removal of metallic oxides may be required.

c. The (**reduced**) (**increased**) heat input common to short circuit GMAW results in low penetration into the base metal, and may result in incomplete fusion if an improper welding technique is used.

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Written Test

d. Oil, grease, and drawing compounds on the electrode wire or the base metal can become potential sources of (**hydrogen**) (**oxygen**) pick-up in a base metal.

e. GMAW shielding gases should be low in moisture content and the welding facility should be free of (**contaminants**) (**dust**).

f. Weld problems such as undercutting, porosity, incomplete fusion, and incomplete joint penetration should be properly identified and (**corrected**) (**evaluated**).

24. Complete a chart of possible causes and corrective actions for undercutting. Write the corrective actions required for possible causes shown in the following chart.

Undercutting	
Possible Causes	Corrective Actions
Travel speed too high	a. ________________
Welding voltage too high	b. ________________
Excessive welding current	c. ________________
Gun angle	d. ________________

25. Complete a chart of possible causes and corrective actions for porosity. Write the corrective actions required for possible causes shown in the following chart.

Porosity	
Possible Causes	Corrective Actions
Inadequate shielding gas coverage	a. ________________ ________________ ________________
Gas contaminants	b. ________________
Electrode contamination	c. ________________
Workpiece contamination	d. ________________ ________________ ________________
Arc voltage too high	e. ________________
Excess contact tube-to-work distance	f. ________________

Written Test

26. Complete a chart of possible causes and corrective actions for incomplete fusion. Write the corrective actions required for possible causes shown in the following chart.

Incomplete Fusion

Possible Causes	Corrective Actions
Weld zone surfaces not free of silt or excessive oxides	a. ______________ ______________ ______________
Insufficient heat input	b. ______________ ______________ ______________
Too large a weld puddle	c. ______________ ______________ ______________
Improper weld technique	d. ______________ ______________ ______________ ______________ ______________
Improper joint design	e. ______________ ______________ ______________
Excessive travel speed	f. ______________

Written Test

27. Complete a chart of possible causes and corrective actions for incomplete joint penetration. Write the corrective actions required for possible causes shown in the following chart.

Incomplete Joint Penetration	
Possible Causes	Corrective Actions
Improper joint preparation	a. ________________ ________________ ________________ ________________
Improper weld technique	b. ________________ ________________ ________________
Inadequate welding current	c. ________________

28. Complete a chart of possible causes and corrective actions for excessive melt-through. Write the corrective actions required for possible causes shown in the following chart.

Excessive Melt-Through	
Possible Causes	Corrective Actions
Excessive heat input	a. ________________ ________________ ________________
Improper joint preparation	b. ________________ ________________

Written Test

29. Complete statements about flow meters and their use in GMAW. Circle the material that best completes each of the following statements.

    a. Flow meters regulate the flow of (**high**) (**low**) pressure gases used in GMAW.

    b. Flow meters measure gas flow in cubic feet per (**minute**) (**hour**) and are calibrated with an adjusting valve on the meter itself.

    c. Floating-ball flow meters must be operated only in the (**vertical**) (**horizontal**) position.

    d. A regulator should be used between the gas supply and the flow meter to assure (**uniform**) (**maximum**) input pressure to the flow meter.

    e. Gas mixtures are available in single cylinders, but gas from separate cylinders can be used with percentages calibrated through (**a mixer**) (**dual regulators**).

30. Select true statements about flow rates for GMAW shielding gases. Place an "X" beside each true statement.

    ______a. Flow rates for GMAW shielding gases are subject to two main variables.

    ______b. Metal thickness and joint design are the major considerations.

    ______c. As welding progresses, electrode extension, travel speed and angle, and environmental conditions may dictate flow rate changes.

31. Solve problems about guidelines for troubleshooting problems. Circle the number of the best solution to each of the following problems.

    a. A coworker at another welding station is having trouble with electrical settings and has changed the amperage and slope settings on the welding machine. The problem seems to be worse. How can you help your coworker?

        (1) Let the other worker solve the problems alone, it is the only way anyone really learns.
        (2) Suggest that all controls be turned back to their original settings, and then change only one variable at a time.
        (3) Have the worker continue changing other settings until the problem is solved.

Written Test

b. A coworker has a problem with gas flow and immediately shuts the equipment down and starts to replace the gas solenoid valve. How can you help your coworker?

(1) Lend the worker a hand with changing out the valve.
(2) Suggest that the worker check the regulator first.
(3) Suggest that the worker check the gas cylinder to make sure it still has gas in it.

***Permission to duplicate this test is granted.**

GMAW Equipment, Applications, and Techniques
Unit 2

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Job Sheet 1—Set Up Wire on a Spool-Type GMAW Wire Feeder. Rating ______

Comments: ____

____

Job Sheet 2—Set Up a Flow Meter and Regulator for a GMAW Shielding Gas. Rating ______

Comments: ____

____

Job Sheet 3—Set Up GMAW Equipment for Short-Circuit Transfer on Mild Steel. Rating ______

Comments: ____

____

Job Sheet 4—Prepare Mild Steel for GMAW. Rating ______

Comments: ____

____

Job Sheet 5—Use Short-Circuit Transfer to Lay Stringer Beads on Mild Steel in the Flat Position. Rating ______

Comments: ____

____

Job Sheet 6—Use Short-Circuit Transfer to Build a Pad on Mild Steel in the Flat Position. Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 7—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position. Rating ______

Comments: ____

____

Job Sheet 8—Break Test a Single-Pass Lap Joint. Rating ______

Comments: ____

____

Job Sheet 9—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position. Rating ______

Comments: ____

____

Job Sheet 10—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position. Rating ______

Comments: ____

____

Job Sheet 11—Bend Test a Welded V-Groove Butt Joint. Rating ______

Comments: ____

____

Job Sheet 12—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position. Rating ______

Comments: ____

____

Job Sheet 13—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position. Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 14—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position. Rating ______

Comments: ____

____

Job Sheet 15—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position. Rating ______

Comments: ____

____

Job Sheet 16—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position. Rating ______

Comments: ____

____

Job Sheet 17—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position. Rating ______

Comments: ____

____

Job Sheet 18—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position. Rating ______

Comments: ____

____

Job Sheet 19—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position. Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 20—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position. Rating ______

Comments: ____

____

Job Sheet 21—Set Up GMAW Equipment for Spray Transfer with Mild Steel. Rating ______

Comments: ____

____

Job Sheet 22—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position. Rating ______

Comments: ____

____

Job Sheet 23—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position. Rating ______

Comments: ____

____

Job Sheet 24—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position. Rating ______

Comments: ____

____

Job Sheet 25—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position. Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 26—Set Up GMAW Equipment for Spray Transfer on Aluminum. Rating ______

Comments: ____

____

Job Sheet 27—Prepare Aluminum for GMAW. Rating ______

Comments: ____

____

Job Sheet 28—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Flat Position. Rating ______

Comments: ____

____

Job Sheet 29—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Flat Position. Rating ______

Comments: ____

____

Job Sheet 30—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Horizontal Position. Rating ______

Comments: ____

____

Job Sheet 31—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Horizontal Position. Rating ______

Comments: ____

____

Job Sheet 32—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Up Position. Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 33—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Up Position. Rating ______

Comments: ____

____

Job Sheet 34—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Down Position. Rating ______

Comments: ____

____

Job Sheet 35—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Down Position. Rating ______

Comments: ____

____

Job Sheet 36—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Overhead Position. Rating ______

Comments: ____

____

Job Sheet 37—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Overhead Position. Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

Teacher Signature ______________________________ Date ____________

Student Signature ______________________________ Date ____________

***Permission to duplicate this form is granted.**

GMAW Equipment, Applications, and Techniques
Unit 2

Information Sheet

1. **Terms and definitions**

   a. **Electrode extension** — The distance between the end of the contact tube and the end of the electrode

   Note: Electrode extension is also called electrode stickout or wire stickout.

   b. **Globular transfer** — A GMAW application in which average currents slightly higher than those used with short-circuit transfer are used to form a droplet that goes onto a base metal as a result of short-circuiting or gravity

   c. **Inductance** — The rate of rise of current as opposed to the final amount of current available; used in short-circuit transfer to increase or decrease the number of short-circuit metal transfers per second

   d. **Short-circuit transfer** — A GMAW application in which low currents, low voltages, and small diameter wires are used to weld in all positions on thin to heavy metals

   e. **Slope** — The slant of the volts versus amp curve, or the volts change per 100 amps

   f. **Slope control** — A power supply control that regulates the amount of pinch force available on welding wire and controls spatter in short-circuit transfer

   g. **Spray transfer** — A GMAW application in which high currents, high voltages, and larger diameter wires are used to weld thicker metals mostly in the flat and horizontal positions

   h. **Travel speed** — The linear rate at which the arc is moved along the weld joint

   i. **Travel angle** — The relationship of the electrode axis with respect to the direction of travel

   j. **Work angle** — The angle between the electrode axis and the adjacent work surface

2. **Characteristics of short-circuit transfer**

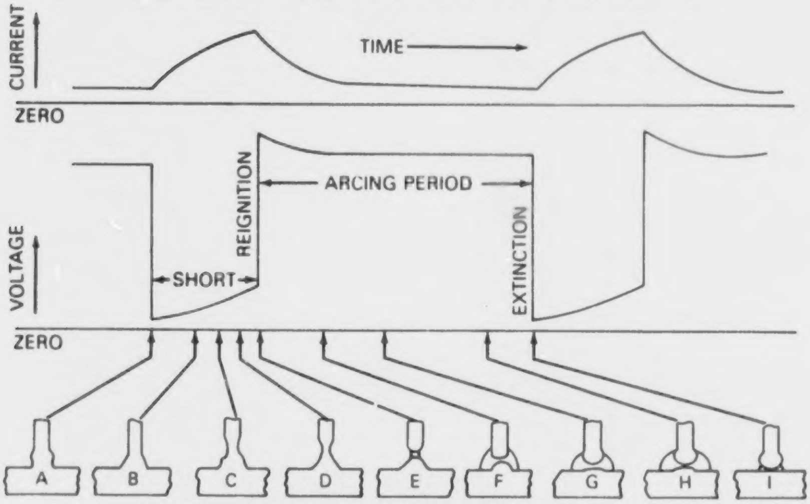
   a. Short-circuit transfer with GMAW is accomplished with a low range of welding currents and small diameter wires.

   b. The small, fast-freezing weld pool created with short-circuit transfer makes it suited for joining thin sections, for out-of-position welding, and for bridging large root openings.

Information Sheet

c. In short-circuit transfer, no metal is transferred across the arc gap, and the open circuit voltage of the power source must be so low that the drop of molten metal at the wire tip cannot transfer until it touches the base metal.

Example: In the following illustration, A, B, C, and D show how the current increases as the arc touches the weld metal. The molten metal at the wire tip pinches off at D and F, initiating an arc as shown in E and F. When the arc is established, the wire melts at the tip, H, and the wire feeds forward to start the next transfer.



Courtesy American Welding Society

d. CO_2 is used as a shielding gas with short-circuit transfer because it promotes deep penetration, but mixtures of CO_2 and argon are used to control spatter.

3. Characteristics of globular transfer

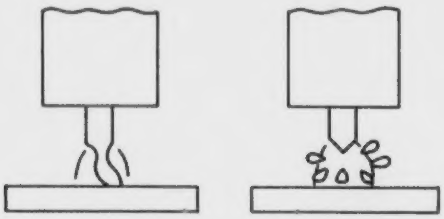
a. Globular transfer with GMAW is characterized by a drop size with a diameter greater than that of the electrode.

b. Globular transfer is accomplished with average currents only slightly higher than those used with short-circuit transfer.

Information Sheet

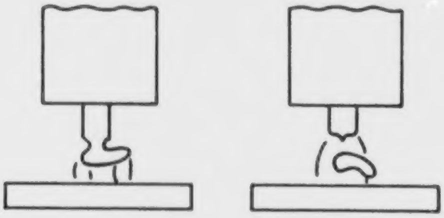
c. One type of globular transfer occurs when the molten drop grows until it detaches by short-circuiting.

Note: The action is similar to short-circuit transfer, but the molten drop comes in contact with the base metal, the wire tip does not.



Courtesy American Welding Society

d. Another type of globular transfer occurs when gravity alone causes the molten drop to fall onto the weld pool.



Courtesy American Welding Society

e. CO_2 is commonly used for globular transfer, especially with mild steels.

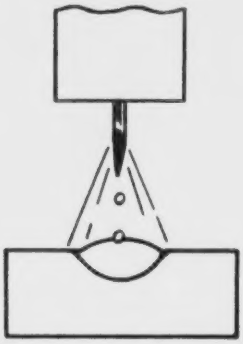
4. **Characteristics of spray transfer**

a. Spray transfer with GMAW is accomplished with the use of direct current and a positive electrode DCEP.

b. The current must reach levels above the "transition current" so that a highly directed stream of individual drops are accelerated by arc forces to velocities which overcome the effects of gravity.

Information Sheet

c. Because the individual drops are equal to or smaller than the diameter of the electrode, and are nearly constantly sprayed through the arc plasma, spatter is virtually eliminated.



Courtesy American Welding Society

d. An argon-rich shielding gas is used to produce the stable spray in spray transfer.

5. **GMAW machine controls and their functions**

   a. **Power supply** — A rectifier-type DC welding machine which controls voltage used in the basic GMAW processes

   b. **Wire feeder** — A roller device used to vary and control the speed at which wire is fed to the welding arc in relation to amperage and wire feed speed

   c. **Gun and cable assembly** — Cable transports power to trigger-operated gun through which the wire, shielding gas, and coolant pass

   d. **Gun** — Trigger-operated on-off device through which wire, shielding gas, and coolant are controlled at the weld zone

   e. **Flowmeter regulator** — Used to reduce high-pressure cylinder gas to low pressure gas so its flow rate can be controlled to the welding gun as measured in CFH (cubic feet per hour)

   f. **Coolant solenoid** — An on-off switch or valve that activates coolant flow in water-cooled GMAW systems

6. **GMAW electrical controls and their functions**

   a. **On-off switch** — Used to start or stop the electrical power to a machine

   b. **Voltage range selector** — Used to control wide-range voltage selection such as 12-28 volts for low range and 20-35 volts for high range

Information Sheet

c. **Fine voltage control** — Used to fine tune the voltage selection within the wide-range setting

d. **Power supply voltmeter** — Used to calibrate and check voltage adjustments

e. **Power supply ammeter** — Used to calibrate and check amperage adjustments

f. **Slope** — Used to add or decrease the rate of resistance change in a welding machine for pinch control which minimizes spatter

g. **Polarity switch** — Used to change polarity from DCEP (DCRP) to DCEN (DCSP) so meters for amps and volts can be properly read

h. **Contactor** — Used to complete circuit through wire feed and function as an on-off device for wire feed

i. **Inductance** — Used to control arc-on time in short-circuit welding to control puddle fluidity and produce a flatter, smoother weld bead

7. **Wire feeder controls and their functions**

a. **On-off switch** — Controls power input into wire feed mechanism

b. **Wire feed control** — Functions as a dual control to regulate wire feed rate in inches-per-minute in relation to amperage

c. **Contactor dropout** — Increases or decreases burn back on electrode extension

d. **Spot weld function** — An on-off device that routes current through a timer which provides a specific time for each trigger activation regardless of how long or briefly the trigger is held

e. **Purge** — A device to permit purging of a shielding gas through the gun without having wire feed at the same time

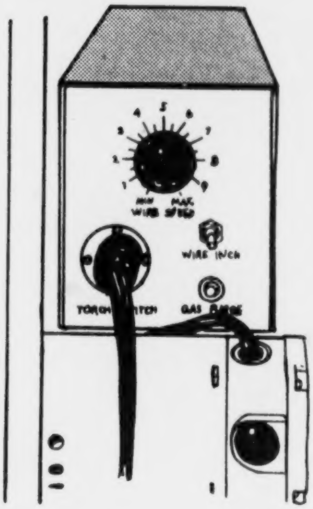
f. **Wire-inch switch** — Used to advance wire for setting up purposes and does not activate other components

g. **Remote unit** — A control that makes voltage adjustment possible in situations where welding activity is far enough away from the welding machine to make it impractical to stop welding in order to make adjustments at the machine

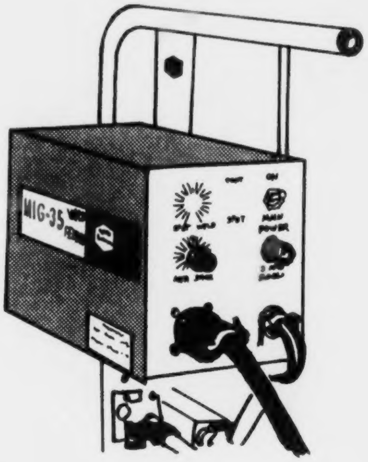
Note: Remote units are self-contained, usually have long extension cords, and some guns have remote adjustment capabilities built in.

Information Sheet

h. **Reverse control** — A handy device that permits excess wire spooled off during loading to be rewound and used, as opposed to wasted



Front



Back

8. Roll adjustment requirements for wire feeders

a. When the tension on wire feeder rolls is too tight, the rolls may flatten or shave the wire.

b. A flattened wire will usually "bird nest" at the feed roll and not feed through the cable.

c. A shaved wire creates small flakes of wire around the feed rolls and could create an electrical hazard or make the wire "bird nest."

d. Wire should not be too tight or too loose.

e. Most wire feeders have rollers for different sizes of wire and the proper roller size should be checked so it will properly roll the size wire being used.

9. Preventive maintenance requirements for wire feeders

a. Feed rolls should be checked and cleaned daily.

b. All electrical connections into and out of the feeder should be checked daily and tightened as required.

c. The drag brake needs to be checked before each use to make sure it feeds off smoothly with no free wheeling.

d. All gas hoses and connections should be inspected for leaks before each operation.

Information Sheet

10. AWS classifications for electrode wires

a. AWS classifications for electrode wire use letter and number designations to identify type of electrode and basic composition.

b. As in other classifications, the letter E indicates electrode, and when followed by the letter R, it indicates that the filler metal may be used as an electrode or welding rod.

c. Interior numbers indicate minimum tensile strength in multiples of 1,000 psi.

d. The letter S indicates a bare solid electrode or rod.

e. Final letter-number classifications indicate special chemical compositions of the electrode wire.

Example: With an ER80S-B2 electrode wire, the E indicates an electrode, the R indicates the wire can be used as a welding rod, the 80 indicates a tensile strength of 80,000 psi, the S indicates a solid electrode, and the B2 indicates that the electrode contains a certain amount of Bismuth, an element with a low melting point to give the electrode that special characteristic.

Note: See Student Supplement 1 for added information about AWS electrode wire classifications.

11. Basic short-circuit electrode wires and their characteristics

a. **ER-70S-2** — Designed for welding all grades of carbon steel as well as some low alloy steels

b. **ER-70S-3** — Designed for welding plain carbon and mild steel, and is the least expensive wire for welding steel

c. **ER-70S-4** — Designed for welding mild steel, and is a medium priced wire

d. **ER-70S-5** — Designed for use with CO_2 shielding gas, and can be used on steel with a somewhat rusty or oily surface

e. **ER-70S-6** — Designed for excellent response with CO_2 shielding gas

f. **ER-70S-7** — Similar to the ER-70S-6, but high manganese content promotes wetting and weld appearance

g. **ER-70S-G** — A special electrode classification whose properties are specified by the manufacturer to meet special specifications for electrode filler wires

h. **ER-80S-D2** — Designed for certain low alloy and high strength steel

Information Sheet

12. **Rules of thumb for GMAW electrode wire selection**

    a. Filler wires used for short-circuit transfer are usually small diameter wires ranging from .020″ to .045″.

    b. Filler wires used for globular transfer start at the upper end of the short-circuit transfer sizes, .045″, and the low end of spray transfer wires, .045″.

    c. Filler wires used for spray transfer are larger diameter wires ranging from .045″ to .125″.

    d. The composition of the electrode wire should match the composition of the base metal on which it will be used.

    e. Since the objective of GMAW is to accomplish a high deposition rate at the lowest cost in materials and time, select the largest electrode size that can be used.

    Note: See Student Supplement 1 for GMAW electrode selections and applications.

13. **Guidelines for storing spools and coils of electrode wire**

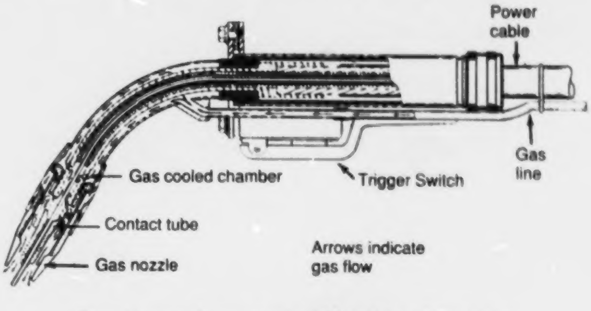
    a. Do not unseal or open spools or coils of electrode wire until they are needed for immediate use.

    b. Store electrode wires in a dry place.

    c. Use spools or coils as soon as possible after opening, and cover or reseal remaining wire prior to storage.

14. **Types of GMAW guns and the characteristics**

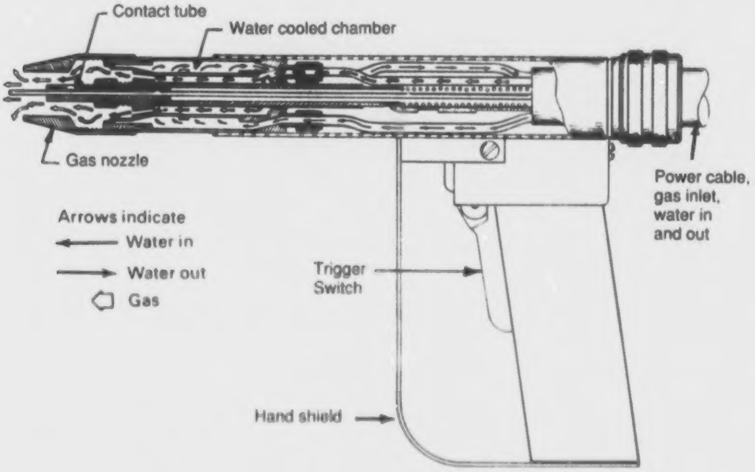
    a. **Air cooled** — Used in short-circuit transfer when the welding application requires short distance welds or weld times that are short or intermittent



Courtesy American Welding Society

Information Sheet

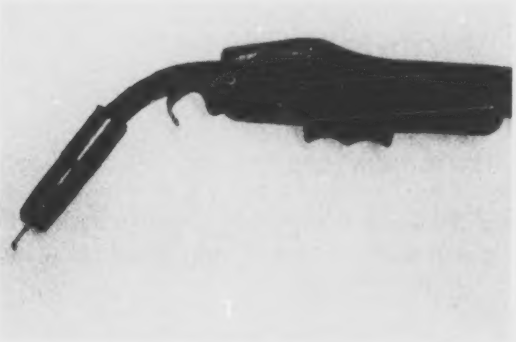
b. **Water cooled** — Used in spray transfer when the welding application requires long distance welds or weld times that are long, especially with larger diameter electrodes


Contact tube
Water cooled chamber
Gas nozzle
Power cable, gas inlet, water in and out
Arrows indicate
Water in
Water out
Gas
Trigger Switch
Hand shield

Courtesy American Welding Society

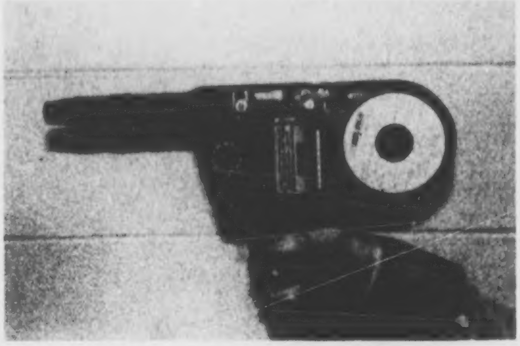
c. **Push** — A gun that has wire pushed directly into it though drive rollers in the wire feed unit

Note: A push gun is typically used to handle heavier diameter hard wires.



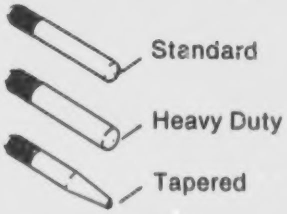
d. **Pull** — A gun that houses a small electric motor that pulls the wire from a spool or reel and feeds it through the contact tips to the weld zone

e. **Spool gun (midget)** — A gun with housing capable of holding a small spool of wire and feeding it through the contact points, and is used primarily in welding aluminum with wire that is too soft to be pushed or pulled a long distance



15. Parts of a GMAW gun tip and their functions

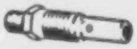
a. **Contact tip** — A copper device used to guide the wire to the weld, and should be selected according to wire size and type of service, standard, heavy duty, or tapered



Courtesy Tweco

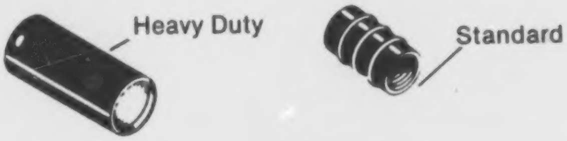
Information Sheet

b. **Gas diffuser** — A copper device that spreads shielding gas out so that it flows evenly over the electrode wire and the weld zone



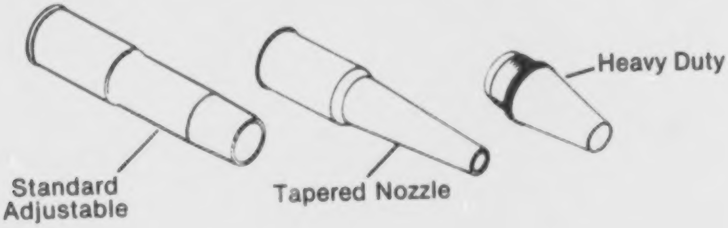
Courtesy Tweco

c. **Nozzle insulator** — Insulates the nozzle from the welding current and holds the nozzle in place



Courtesy Tweco

d. **Nozzle** — Directs and holds shielding gas round the weld zone, and may be standard, tapered for tight places, or heavy duty for continuous welding



Courtesy Tweco

16. **Steps in assembling contact tips, gas diffusers, nozzles, and insulators**

    a. Screw the gas diffuser into the end of the conductor tube assembly with an adjustable wrench, and then tighten the Allen screw that holds the wire-feed conduit.

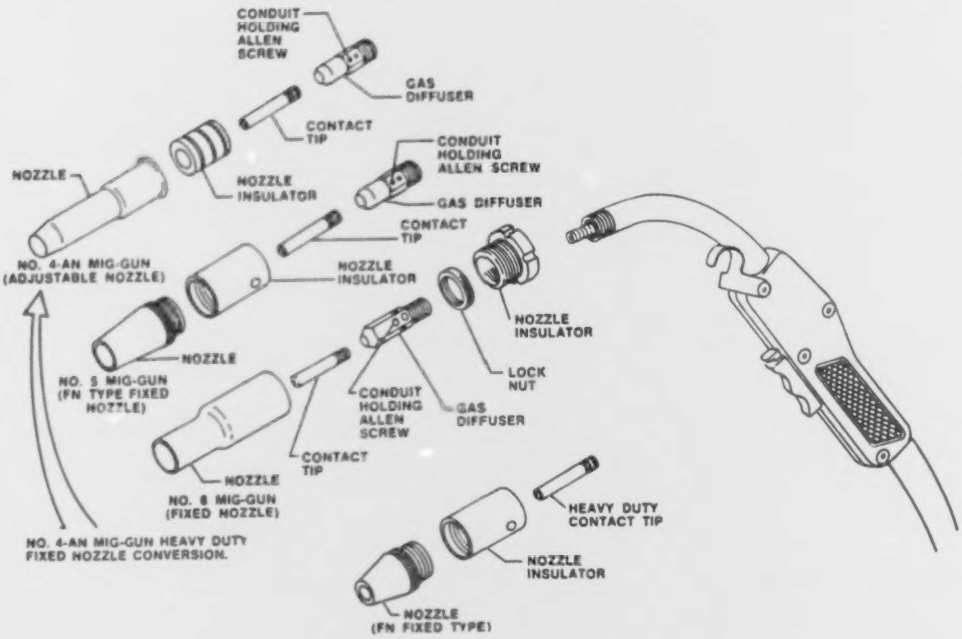
    b. Screw the contact tip into the gas diffuser and snug it tight with pliers, but be careful not to damage the contact tip.

    c. Screw the nozzle insulator over the diffuser and contact tip and hand tighten.

Information Sheet

d. Slide the nozzle over the split-spring rings of the insulator and adjust for electrode extension.

Note: Gun tip components all require careful assembly, and the variety of components is shown in the following illustration.


CONDUIT HOLDING ALLEN SCREW
GAS DIFFUSER
CONTACT TIP
NOZZLE
NOZZLE INSULATOR
CONDUIT HOLDING ALLEN SCREW
GAS DIFFUSER
CONTACT TIP
NO. 4-AN MIG-GUN (ADJUSTABLE NOZZLE)
NOZZLE INSULATOR
NOZZLE INSULATOR
NOZZLE
NO. 5 MIG-GUN (FN TYPE FIXED NOZZLE)
LOCK NUT
CONDUIT HOLDING ALLEN SCREW
GAS DIFFUSER
CONTACT TIP
NOZZLE
NO. 6 MIG-GUN (FIXED NOZZLE)
NO. 4-AN MIG-GUN HEAVY DUTY FIXED NOZZLE CONVERSION.
HEAVY DUTY CONTACT TIP
NOZZLE INSULATOR
NOZZLE (FN FIXED TYPE)

Courtesy Tweco

17. Maintenance requirements for GMAW guns

a. Air cooled guns:

(1) Select contact tips the right size for the wire being used and keep contact tips tight.

(2) Keep gas diffusers tight on conductor tubes (goose necks).

(3) Clean nozzle and insulator periodically so the gas flow will not slow down.

(4) Spray nozzle with anti-spatter gel so it will remain as spatter free as possible.

(5) Keep cables free of kinks and pinches at all times.

Note: General maintenance requirements for air cooled guns applies to all GMAW guns.

Information Sheet

b. Water cooled guns:

  (1) Check daily for leaks.

  (2) Check water or coolant supply daily to make sure it is adequate for cooling requirements.

  (3) Check cables for kinks or pinches.

c. Spool guns:

  (1) Check feed roll tension at the beginning of each welding activity to make sure the wire is not being flattened or shaved.

  (2) Check gas fittings and hoses periodically for leaks.

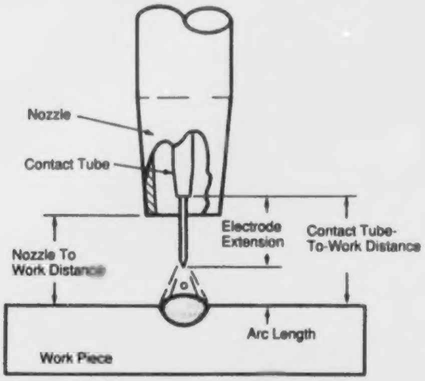
  (3) Keep contact tips and gas diffusers tight so resistance will not cause overheating at the gun.

18. Electrode extension and its function in GMAW

a. Electrode extension gives an operator control of slight but critical adjustments of amperage and voltage needed to correct spatter, penetration, and bead width.

b. Too much electrode extension decreases amperage and slightly increases voltage; this results in more arc which produces spatter and poor penetration.

c. Too little electrode extension increases amperage and slightly decreases voltage; this results in less arc which gives no spatter and good penetration, but it produces a narrow bead with overall poor fusion.



Courtesy American Welding Society

Information Sheet

d. Electrode extension for short-circuit transfer is ¼" to ½".

e. Electrode extension for spray transfer is ½" to 1".

19. **GMAW shielding gases and their applications**

a. Argon is the most frequently used shielding gas for welding nonferrous metals because it produces a clean, narrow bead with deep penetration in both short-circuit and spray transfer.

b. Helium is mixed with argon for some aluminum welding in both short-circuit and spray transfer, but helium does not produce the stable arc provided by argon.

c. CO_2 is used primarily on carbon steels because it is far less expensive than other shielding gases, but because CO_2 can produce an unstable arc and spatter, it requires electrode wires with deoxidizing agents.

Note: A CO_2-argon mixture in varying percentages can be used to alleviate unstable arc problems and spatter.

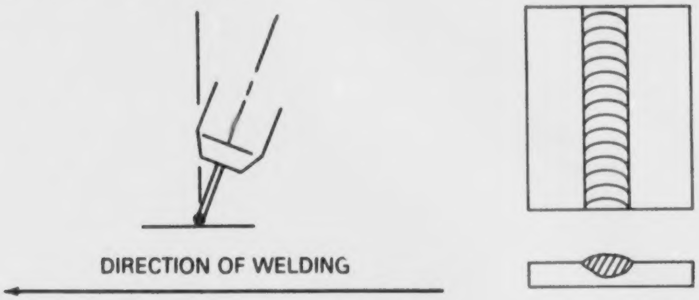
d. Oxygen is used in varying percentages with argon for spray transfer on both mild and stainless steels.

20. **GMAW welding techniques and their characteristics**

a. Forehand welding with a lead angle means that the electrode points in the direction of travel.

Note: Forehand welding is sometimes referred to as the "push" technique.

b. The forehand technique decreases penetration, gives a wider, flatter bead, and is mostly used on thicker metals.



Courtesy American Welding Society

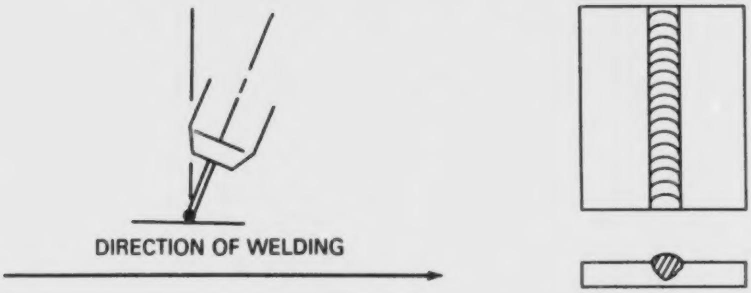
Information Sheet

c. Backhand welding with a drag angle means that the electrode points opposite the direction of travel.

   Note: Backhand welding is sometimes referred to as the "drag" or "pull" technique.

d. The backhand welding technique increases penetration, gives a more convex, narrower bead, provides a more stable arc, and leaves less spatter on the workpiece.

e. The backhand technique is mostly used on thinner metals.



Courtesy American Welding Society

21. **Techniques for properly ending a GMAW weld**

a. The first step in a common technique for ending a GMAW weld is to release the gun trigger just as the bead reaches the end of the weld.

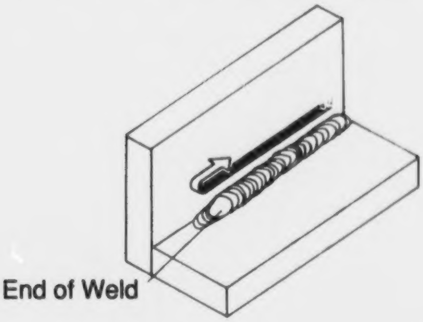
b. Hold the gun in place and hesitate for just a second to keep the molten puddle covered with shielding gas, and then pull the gun away.

   Note: The slight hesitation after releasing the trigger is the key to make this technique work because the burn-back control will continue action just long enough for the crater to fill and end the weld properly by protecting the weld puddle from contamination.

Information Sheet

c. An alternate technique for ending a GMAW weld is to reverse the travel direction before breaking the arc.

Note: The alternate technique is essential for welding out of corners where the weld has to start at a corner and be completed at a more accessible point.



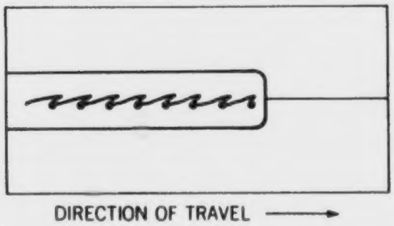
Courtesy Union Carbide Corporation, Linde Division

d. After breaking the arc, keep the gun in place briefly so the crater will be shielded until it completely solidifies.

22. **Techniques for position welding with GMAW**

a. For single-pass butt joints in the flat position, use a slight back-stepping motion, but for flat position open-root butt joints, use a small weave.

Example: For a single pass square-groove butt joint, use a travel angle of 5° to 10° and a work angle of 90°.

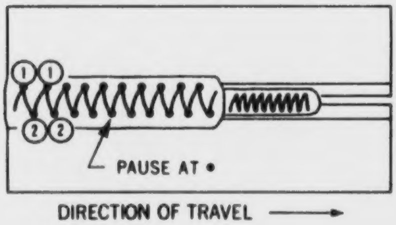


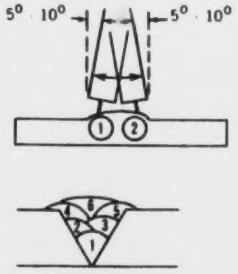
Courtesy Union Carbide Corporation, Linde Division

Information Sheet

b. For fill and cover passes in the flat position, weave to desired width.

Example: For a multi-pass V-groove butt joint, use a travel angle of 5° to 10° and a work angle of 90°.


1
1
2
2
PAUSE AT •
DIRECTION OF TRAVEL

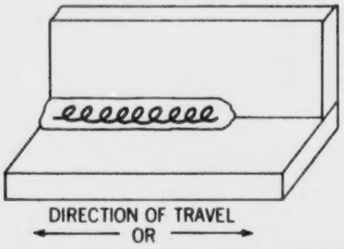

5° - 10°
5° - 10°
1
2
1
2
3
4
5
6

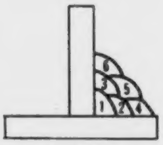
Weld bead placement for multipass butt weld

Courtesy Union Carbide Corporation, Linde Division

c. For fillet welds in the horizontal position, use a circular weave.

Example: Use a travel angle of 5° to 10° and a work angle of 45°.

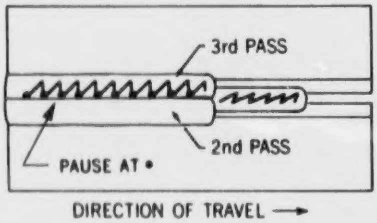

DIRECTION OF TRAVEL
OR

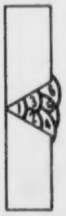


Weld bead placement for multipass fillet weld

d. For V-groove butt joints in the horizontal position, use a weave to accomplish the desired width.

Example: For a V-groove butt joint, use a travel angle of 5° to 10° and a work angle of 90°.


3rd PASS
2nd PASS
PAUSE AT •
DIRECTION OF TRAVEL



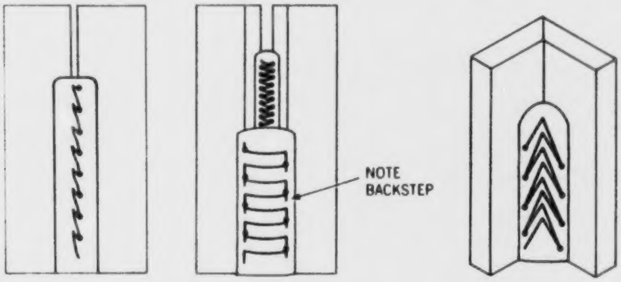
Weld bead placement for multipass butt weld

Courtesy Union Carbide Corporation, Linde Division

Information Sheet

e. For both single-pass and multi-pass groove welds, and for fillet welds in the vertical up position, use a weaving technique.

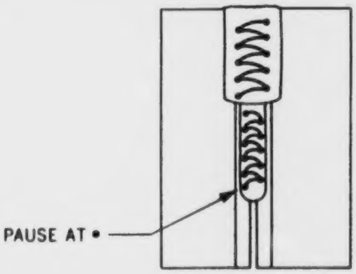
Example: Use a travel angle of 10° to 15° and a work angle of 90°.



Courtesy Union Carbide Corporation, Linde Division

f. For all welds in the vertical down position, take special care to keep the arc in the leading edge of the puddle so the molten metal will not run around the arc and cause cold lapping.

Example: Use a travel angle of 5° to 10° and a work angle of 90°. Use a weave technique for fillet welds and for single-pass V-groove welds. Fill and cover with same weave technique.



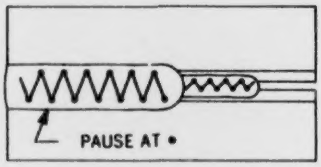
* Be sure to angle gun towards walls when weaving

Courtesy Union Carbide Corporation, Linde Division

Information Sheet

g. For both groove and fillet welds in the overhead position, use a weaving technique.

Example: Use a travel angle of 5° to 10° and a work angle of 90°.



* Be sure to angle gun toward walls when weaving.

Courtesy Union Carbide Corporation, Linde Division

23. Conditions that require special attention with GMAW

a. Base metal cleanliness is more critical with GMAW than with some other welding processes.

Examples: Both SMAW and SAW have fluxing compounds that scavage and cleanse the molten weld deposit of oxides and gas-forming compounds. GMAW does not provide such action.

b. Preweld and interpass cleaning are essential for GMAW, and especially for aluminum where chemical cleaning and/or mechanical removal of metallic oxides may be required.

c. The reduced heat input common to short circuit GMAW results in low penetration into the base metal, and may result in incomplete fusion if an improper welding technique is used.

Note: Reduced heat input is desirable on thin gauge materials and for out-of-position welding, but incomplete fusion can still occur, especially in root areas or along groove faces.

d. Oil, grease, and drawing compounds on the electrode wire or the base metal can become potential sources of hydrogen pick-up in a base metal.

e. GMAW shielding gases should be low in moisture content and the welding facility should be free of contaminants.

f. Weld problems such as undercutting, porosity, incomplete fusion, and incomplete joint penetration should be properly identified and corrected.

Note: The charts in the following four objectives present possible causes and corrective actions for common GMAW problems.

Information Sheet

24. Possible causes and corrective actions for undercutting

Undercutting	
Possible Causes	Corrective Actions
Travel speed too high	Reduce travel speed.
Welding voltage too high	Reduce voltage.
Excessive welding current	Reduce wire feed speed.
Gun angle	Change gun angle so that arc force can aid in metal placement.

25. Possible causes and corrective actions for porosity

Porosity	
Possible Causes	Corrective Actions
Inadequate shielding gas coverage	Increase gas flow to displace air from the weld zone, or decrease gas flow to avoid turbulence and air entrapment in the weld zone.
Gas contaminants	Use welding grade shielding gases.
Electrode contamination	Use only clean, dry electrode wire.
Workpiece contamination	Perform better preweld cleaning. Use more highly deoxidizing electrode wire.
Arc voltage too high	Reduce voltage.
Excess contact tube-to-work distance	Reduce electrode extension.

Information Sheet

26. Possible causes and corrective actions for incomplete fusion

Incomplete Fusion	
Possible Causes	Corrective Actions
Weld zone surfaces not free of silt or excessive oxides	Clean weld zone surface free of mill scale before welding.
Insufficient heat input	Increase wire feed speed and arc voltage, and reduce electrode extension.
Too large a weld puddle	Minimize weaving to produce a more controllable weld puddle. Increase travel speed.
Improper weld technique	Keep electrode directed at the leading edge of the puddle. When weaving, dwell momentarily on the side walls of grooves. Provide improved access to roots of joints.
Improper joint design	Use angle groove large enough to allow access to bottom of the groove and sidewalls with proper extension, or use "U" or "J" groove.
Excessive travel speed	Reduce travel speed.

27. Possible causes and corrective actions for incomplete joint penetration

Incomplete Joint Penetration	
Possible Causes	Corrective Actions
Improper joint preparation	Provide proper access to the bottom of the groove while maintaining proper electrode extension. Reduce excessively large root face. Increase the root gap in butt joints, and increase the depth of back gouge.
Improper weld technique	Maintain electrode angle normal to work surface to achieve maximum penetration. Keep arc on leading edge of puddle.
Inadequate welding current	Increase the wire feed speed.

Information Sheet

28. Possible causes and corrective actions for excessive melt-through

Excessive Melt-Through	
Possible Causes	Corrective Actions
Excessive heat input	Reduce wire feed speed and voltage. Increase travel speed.
Improper joint preparation	Reduce root opening. Increase root face dimensions.

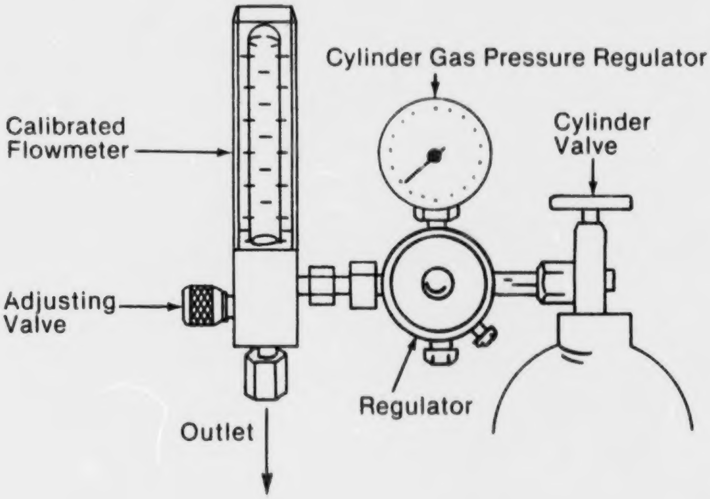
29. Flow meters and their use in GMAW

a. Flow meters regulate the flow of low pressure gases used in GMAW.

b. Flow meters measure gas flow in cubic feet per hour and are calibrated with an adjusting valve on the meter itself.

c. Floating-ball flow meters must be operated only in the vertical position.

d. A regulator should be used between the gas supply and the flow meter to assure uniform input pressure to the flow meter.



Note: A regulator delivers constant working pressure regardless of variations at the gas source, and dual stage regulators do an even better job when source pressure varies. Some regulators also have a built-in flowmeter.

e. Gas mixtures are available in single cylinders, but gas from separate cylinders can be used with percentages calibrated through a mixer.

Information Sheet

30. Flow rates for GMAW shielding gases

a. Flow rates for GMAW shielding gases are subject to many variables.

b. Metal thickness and joint design are important considerations as well as wire diameter, current, and wire feed speed.

c. As welding progresses, electrode extension, travel speed and angle, and environmental conditions may dictate flow rate changes.

Note: See Student Supplement 4 for flow rate recommendations related to other typical conditions for GMAW applications.

31. Guidelines for troubleshooting GMAW problems

a. Try to isolate electrical or mechanical problems from process problems.

Example: Problems with arc control may be electrical, but they could also be caused by air drafts in the workplace.

b. Change only one variable at a time so you can use a logical process of elimination without creating a totally different problem.

c. Don't make hasty decisions about the source of a problem.

Example: If you replace a gas solenoid valve to solve a problem with gas flow, you will not feel extremely intelligent when you discover that the real problem was an empty gas cylinder.

d. Follow manufacturer's troubleshooting guidelines for all equipment.

e. Observe all safety rules when troubleshooting, especially when troubleshooting electrical problems.

Note: See Student Supplement 3 for GMAW troubleshooting guidelines as outlined by the American Welding Society.

GMAW Equipment, Applications, and Techniques
Unit 2

Student Supplement 1—Recommended Electrodes for GMAW

Base Material			AWS Electrode Specification (Use latest edition)
Type	**Classification**	**Electrode Classification**	
Aluminum and aluminum alloys (ASTM Standards Volume 2.02)	1100	ER4043	A5.10
	3003, 3004	ER5356	
	5052, 5454	ER5554, ER5556, or ER5183	
	5083, 5086, 5456	ER5556 or ER5356	
	6061, 6063	ER4043 or ER5356	
Magnesium alloys (ASTM Standards Volume 2.02)	AZ10A	ERAZ61A, ERAZ92A	A5.19
	AZ31B, AZ61A, AZ80A	ERAZ61A, ERAZ92A	
	ZE10A	ERAZ61A, ERAZ92A	
	ZK21A	ERAZ92A	
	AZ63A, AZ81A, AZ91C	EREZ33A	
	AZ92A, AM100A	EREZ33A	
	HK31A, HM21A, HM31A	EREZ33A	
	LA141A	EREZ33A	
Copper and copper alloys (ASTM Standards Volue 2.01)	Commercially pure	ERCu	A5.7
	Brass	ERCuSi-A, ERCuSn-A	
	Cu-Ni alloys	ERCuNi	
	Manganese bronze	ERCuAl-A2	
	Aluminum bronze	ERCuAl-A2	
	Bronze	ERCuSn-A	
Nickel and nickel alloys (ASTM Standards Volume 2.04)	Commercially pure	ERNi	A5.14
	Ni-Cu alloys	ERNiCu-7	
	Ni-Cr-Fe alloys	ERNiCrFe-5	
Titanium and titanium alloys (ASTM Standards Volume 2.04)	Commercially pure	ERTi-1,-2,-3,-4	A5.16
	Ti-6 AL-4V	ERTi-6Al-4V	
	Ti-0.15Pd	ERTi-0.2Pd	
	Ti-5Al-2 5Sn	ERTi-5Al-2.5Sn	
	Ti-13V-11Cr-3AL	ERTi-13V-11Cr-3AL	
Austenitic stainless steels (ASTM Standards Volume 1.04)	Type 201	ER308	A5.9
	Types 301, 302, 304 & 308	ER308	
	Type 304L	ER308L	
	Type 310	ER310	
	Type 316	ER316	
	Type 321	ER321	
	Type 347	ER347	
Carbon steels	Hot and cold rolled plain carbon steels	E70S-3, or E70S-1 E70S-2, E70S-4 E70S-5, E70S-6	A5.18

Courtesy American Welding Society

GMAW Equipment, Applications, and Techniques
Unit 2

Student Supplement 2—Recommended GMAW Shielding Gases

GMAW Shielding Gases for Short Circuiting Transfer

Metal	Shielding Gas	Thickness	Advantages
Carbon steel	75% argon +25% CO$_2$	Less than 1/8 in. (3.2 mm)	High welding speeds without burn-through; minimum distrotion and spatter.
	75% argon +25% CO$_2$	More than 1/8 in. (3.2 mm)	Minimum spatter; clean weld appearance; good puddle control in vertical and overhead positions.
	Argon with 5-10% CO$_2$	—	Deeper penetration; faster welding speeds.
Stainless steel	90% helium + 7.5% argon + 2.5% CO$_2$	—	No effect on corrosion resistance; small heat-affected zone; no undercutting; minimum distortion.
Low alloy steel	60-70% helium +25-35% argon +4.5% CO$_2$	—	Minimum reactivity; excellent toughness; excellent arc stability, wetting characteristics, and bead contour; little spatter.
	75% argon +25% CO$_2$	—	Fair toughness; excellent arc stability, wetting characteristics, and bead contour; little spatter.
Aluminum, copper magnesium, nickel, and their alloys	Argon & argon + helium	Over 1/8 in. (3.2 mm)	Argon satisfactory on sheet metal; argon-helium preferred base material.

GMAW Shielding Gases for Spray Transfer

Metal	Shielding Gas	Thickness	Advantages
Aluminum	100% Argon	0 to 1 in. (0 to 25 mm)	Best metal transfer and arc stability; least spatter.
	35% argon -65% helium	1 to 3 in. (25 to 76 mm)	Higher heat input than straight argon; improved fusion characteristics with 5XXX series Al-Mg alloys.
	25% argon -75% helium	Over 3 in. (76 mm)	Highest heat input; minimizes porosity
Magnesium	100% Argon	—	Excellent cleaning action.
Steel carbon	95% Argon +3.5% oxygen	—	Improves arc stability; produces a more fluid and controllable weld puddle; good coalescence and bead contour; minimizes undercutting; permits higher speeds than pure argon.
	90% Argon +8/10% carbon dioxide	—	High-speed mechanized welding; low-cost manual welding.
Steel low-alloy	98% Argon -2% oxygen	—	Minimizes undercutting; provides good toughness.
Steel stainless	99% Argon -1% oxygen	—	Improves arc stability; produces a more fluid and controllable weld puddle, good coalescence and bead contour; minimizes undercutting on heavier stainless steels.
	98% Argon -2% oxygen	—	Provides better arc stability, coalescence, and welding speed than 1 percent oxygen mixture for thinner stainless steel materials.
Nickel, copper, and their alloys	100% Argon	Up to 1/8 in. (3.2 mm)	Provides good wetting; decreases fluidity of weld metal.
	Argon -helium	—	Higher heat inputs of 50 & 75 percent helium mixtures offset high heat dissipation of heavier gages.
Titanium	100% Argon	—	Good arc stability; minimum weld contamination; inert gas backing is required to prevent air contamination on back of weld area.

Courtesy American Welding Society

GMAW Equipment, Applications, and Techniques
Unit 2

Student Supplement 3—GMAW Troubleshooting

Troubleshooting Electrical Problems Encountered in Gas Metal Arc Welding

Problem	Possible Cause	Remedy
Difficult arc starting	Wrong polarity	Check polarity; reverse leads if necessary.
	Poor work lead connection	Secure work lead connection
Irregular wire feed and burnback	Power circuit fluctuations	Check line voltage
	Polarity wrong	Check polarity; reverse leads if necessary
Welding cables overheating	Cables are too small or too long	Check current carrying requirements - replace or shorten if necessary
	Cable connections loose	Tighten
No wire feed speed control	Broken or loose wires in control circuit	Check and repair if necessary
	Bad P.C. board in governor	Replace P.C. board
Unstable arc	Cable connections are loose	Tighten connections
Electrode won't feed	Control circuit fuse blown	Replace fuse
	Fuse blown in power source	Replace fuse
	Defective gun trigger switch or broken wire leads	Check connections; replace switch
	Drive motor burned out	Check and replace
Wire feeds but no gas flows	Failure of gas valve solenoid	Replace
	Loose or broken wires to gas valve solenoid	Check and repair if necessary
Electrode wire feeds but is not energized (no arc)	Poor workpiece connection	Tighten if loose; clean work of paint, rust, etc.
	Loose cable connections	Tighten
	Primary contactor coil or points defective	Repair or replace
	Contactor control leads broken	Repair or replace
Porosity in weld	Loose or broken wires to gas solenoid valve	Repair or replace

Courtesy American Welding Society

Note: The AWS troubleshooting guidelines are arranged on single pages so they can be placed alongside each other to afford a better overall view of how problems overlap. In other words, an electrical problem may be the result of a mechanical problem, or a process problem the result of a mechanical problem. The "systems" approach to troubleshooting will help solve problems that occur as welding is in progress. Problems with weld quality after the weld is made are covered in earlier objectives.

Student Supplement 3

Troubleshooting Mechanical Problems Encountered in Gas Metal Arc Welding

Problem	Possible Cause	Remedy
Irregular wire feed and burnback	Insufficient drive roll pressure	Adjust
	Contact tube plugged or worn	Clean or replace
	Kinked electrode wire	Cut out, replace spool
	Coiled gun cable	Straighten cables, hang the wire feeder
	Conduit liner dirty or worn	Clean or replace
	Conduit too long	Shorten or use push-pull drive system
Electrode wire wraps around drive roll (•birdnesting•)	Excessive feed roll pressure	Adjust
	Incorrect conduit liner or contact tip	Match liner and contact tip to electrode size
	Misaligned drive rolls or wire guides	Check and align properly
	Restriction in gun or gun cable	Remove restriction
Heavily oxidized weld deposit	Air/water leaks in gun and cables	Check for leaks and repair or replace as necessary
	Restricted shield gas flow	Check and clean nozzle
Electrode wire stops feeding while welding	Excess or insufficient drive roll pressure	Adjust
	Wire drive rolls misaligned or worn	Realign and/or replace
	Liner or contact tube plugged	Clean or replace
Wire feeds but no gas flows	Gas cylinder is empty	Replace and purge lines before welding
	Gas cylinder valve closed	Open cylinder valve
	Flow meter not adjusted	Adjust to give flow specified in the procedure
	Restriction in gas line or nozzle	Check and clean
Porosity in the weld bead	Failed gas valve solenoid	Repair or replace
	Gas cylinder valve closed	Turn valve on
	Insufficient shielding gas flow	Check for restrictions in gas line or nozzle and correct
	Leaks in gas supply lines (including the gun)	Check for leaks (especially at connections) and correct
Wire feed motor operates but wire does not feed	Insufficient drive roll pressure	Adjust
	Incorrect wire feed rolls	Match feed rolls to wire size and type
	Excessive pressure on wire spool brake	Decrease brake pressure
	Restriction in the conduit liner or gun	Check liner and contact tip. Clean and/or replace
	Incorrect liner or contact tube	Check and replace with correct size
Welding gun overheats	Pinched or clogged coolant line	Check and correct
	Low coolant level in pump reservoir	Check and add coolant as necessary
	Water pump not functioning correctly	Check and repair or replace

Courtesy American Welding Society

Student Supplement 3

Troubleshooting Process Problems Encountered in Gas Metal Arc Welding

Problem	Possible Cause	Remedy
Unstable arc	Weld joint area dirty	Clean to remove scale, rust, etc.
Heavily oxidized weld deposit	Improper gun angle	Use approximately 15° lead or trail angle
	Excessive nozzle to work distance distance	Reduce. Should be approximately 1/2 to 3/4"
	Air drafts	Protect weld area from drafts
	Contact tube not centered in the gas nozzle distance	Center contact tube
Porosity in the weld bead	Dirty base material	Clean to remove scale, rust, etc.
	Excessive wire feed speed	Reduce.
	Moisture in the shielding gas	Replace gas cylinder
	Contaminated electrode	Keep wire protected while using. Clean wire before it enters feeder.
Electrode wire stubs into the workpiece	Excessive wire feed speed	Reduce speed
	Arc voltage too low	Increase voltage
	Excessive slope set on power source (for short circuiting transfer)	Reset to reduce slope
Excessive spatter	Excessive arc voltage	Reduce voltage
	Insufficient slope set on power source (for short circuiting transfer)	Increase slope setting
	Contact tube recessed too far in nozzle	Adjust or replace with longer one
	Excessive gas flow rate	Reduce flow.
Welding gun overheats	Excessive amperage for gun	Reduce amperage or change to higher capacity gun

Courtesy American Welding Society

GMAW Equipment, Applications, and Techniques
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Student Supplement 4—Gas Metal Arc Welding Conditions

Table 4.8
Typical Conditions for Gas Metal Arc Welding of Carbon and Low Alloy Steel in the Flat Position

Material Thickness			Wire Diameter		Current Voltage[1]		Wire Feed Speed			Gas Flow	
in.	mm	Type of Weld	in.	mm	amps	volts	IPM	mm/s	Shielding Gas[2]	CFH	LPM
.062	1.6	Butt[3]	.035	0.9	95	18	150	64	Ar 75%, CO_2 -25%	25	12
.125	3.2	Butt[3]	.035	0.9	140	20	250	106	Ar 75%, CO_2 25%	25	12
.187	4.7	Butt[3]	.035	0.9	150	20	265	112	Ar 75%, CO_2 25%	25	12
.250	6.4	Butt[3]	.035	0.9	150	21	265	112	Ar 75%, CO_2 25%	25	12
.250	6.4	Butt[4]	.045	1.1	200	22	250	106	Ar 75%, CO_2 -25%	25	12

1. Direct current electrode positive.
2. Welding grade CO_2 may also be used.
3. Root opening of .03 in. (0.8 mm).
4. Root opening of .062 in. (1.6 mm).

Table 4.9
Typical Conditions for Gas Metal Arc Welding of Aluminum in the Flat Position

Material Thickness			Wire Diameter		Current Voltage*		Wire Feed Speed			Gas Flow	
in.	mm	Type of Weld	in.	mm	amps	volts	IPM	mm/s	Shielding Gas	CFH	LPM
.062	1.6	Butt	.030	0.8	90	18	365	155	Argon	30	14
.125	3.2	Butt	.030	0.8	125	20	440	186	Argon	30	14
.187	4.8	Butt	.045	1.1	160	23	275	116	Argon	35	16
.250	6.4	Butt	.045	1.1	205	24	335	142	Argon	35	16
.375	9.5	Butt	.063	1.6	240	26	215	91	Argon	40	19

* Direct current electrode positive.

Courtesy American Welding Society

GMAW Equipment, Applications, and Techniques
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Job Sheet 1—Set Up Wire on a Spool-Type GMAW Wire Feeder

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Proper removal of old spool	______
New spool set up to feed from bottom	______
Wire properly fed through roller	______
Wire-inch control properly used	______
Pinch test used to test wire tension	______
Wire properly prepared for welding activity	______

A. Tools and materials

- GMAW machine and accessories
- Personal safety clothing and equipment
- GMAW wire spool or coil
- Screwdriver
- Adjustable wrench
- Wire-cutting pliers
- Fine-cut file
- Nozzle spray or gel

B. Procedure

☐ 1. Shut off input power to the power supply and wire feeder.

☐ 2. Get a firm hold on the wire near the pressure rollers, if you are replacing a partial spool.

☐ 3. Cut the wire with wire-cutting pliers near the pressure rollers.

☐ 4. Locate the small-diameter hole on the outside edge of the spool, put the end of the cut wire into it, and tie the loose end.

☐ 5. Remove the nozzle from the GMAW gun.

Job Sheet 1

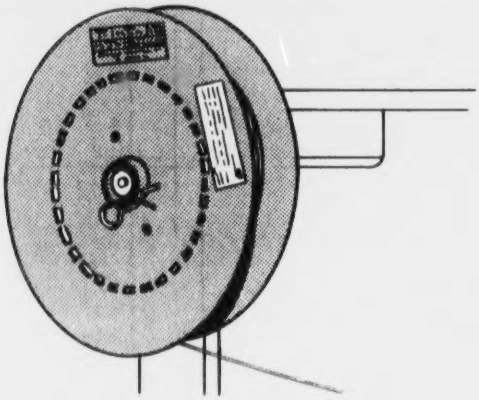
☐ 6. Press the gun trigger switch and run the cut wire past the pressure rollers, and then release the gun trigger switch.

☐ 7. Pull the remaining wire through the cable and dispose of it, if you are replacing a partial or empty spool.

☐ 8. Remove the contact tip.

☐ 9. Remove the retaining collar that holds the spool in place by loosening the thumb screw or removing the cotter pin that secures it.

Note: Different manufacturers of GMAW equipment use various methods of spool attachment.



☐ 10. Remove the empty or partially used spool from the spindle and set it aside.

Note: The following procedures are for initial setup or for wire replacement.

☐ 11. Locate the end of the wire on the new spool and position the new spool so that wire will feed from the bottom of the spool into the wire feeder.

Caution: Do not remove the free end of the wire from the retaining hole where it is secured or you will have wire all over the place.

☐ 12. Place the new spool of wire onto the spindle and make sure the drag brake pin slips into the proper hole.

Job Sheet 1

☐ 13. Place the retaining collar back on the spindle, force it tightly against the reel, and tighten the thumb screw or replace the cotter pin that secures it.

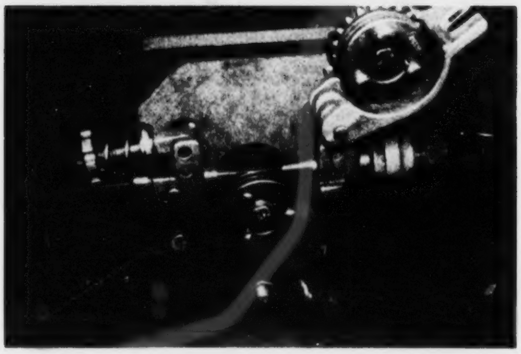
☐ 14. Locate the end of the wire on the spool, free it from the retaining hold, and clip the end of the wire.

Caution: Hang on to the free end of the wire firmly throughout this procedure.

☐ 15. Use a file to smooth the sharp end of the wire.

☐ 16. Release pressure on the top rollers by loosening with a screwdriver or thumb screw knob, then raise the top roller.

☐ 17. Guide the clean, free end of the wire through the insulated input guide and use both hands to push and pull the wire across the top of the bottom feed roller and through the insulated output guide.



☐ 18. Continue pushing and pulling the wire until it moves into and through the wire feed power assembly 2″ to 3″.

Caution: Do not force the wire into the wire feed assembly, just work it back and forth until it fits smoothly.

☐ 19. Bring top feed roll down so that the wire lies in the groove between both the rollers.

Job Sheet 1

☐ 20. Use a screwdriver, or thumb screw, to tighten the pressure adjusting screw to provide operating pressure between the bottom and top rollers.

Caution: Do not overtighten the adjusting screw and cause the wire to flatten out.

☐ 21. Turn power supply on and wire feed power on.

☐ 22. Position gun so that the cable conduit between the wire feeder and gun is straight.

Note: Use the wire-inch for the following adjustment because it will help keep from shorting out the gas diffuser and wasting expensive shielding gas. If the machine does not have a wire-inch, turn off the gas supply and avoid grounding out the bare gas diffuser.

☐ 23. Turn the wire-inch on or set wire feed control to half speed and feed the wire through the cable conduit to the gun while testing tension on the feed roller with the following procedures:

  a. Pinch the wire with finger pressure just ahead of the insulated input guide.

  b. If a slight pinching pressure will stop the wire from feeding through, the tension is probably all right.

  c. If a slight pinching pressure will not stop the wire from feeding through, the tension is probably too much.

☐ 24. Turn off power supply and wire feed supply, then replace the contact tip required for the size wire you are using, then snug the contact tip with pliers carefully.

☐ 25. Replace nozzle over contact tip.

☐ 26. Have your instructor check your work.

Note: The procedure for replacing a coil-type wire reel is essentially the same as a spool-type reel except that the coil-type reel has a spring-loaded device to secure and release it so that the reel separates into two halves in order for a replacement coil to be installed.

Job Sheet 1

☐ 27. Adjust machine for specified welding activity.

☐ 28. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
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Job Sheet 2—Set Up a Flow Meter and Regulator for a GMAW Shielding Gas

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Cylinder safety	______
Regulator setup	______
Flow meter setup	______
Cfh adjustment	______

A. Tools and materials

GMAW machine and accessories
Selected shielding gas cylinder
Flow meter and regulator
Adjustable wrench or 1⅛″ open-end wrench
Safety glasses

B. Procedure

☐ 1. Make sure the gas cylinder is safely secured in an upright position.

☐ 2. Remove the cylinder cap.

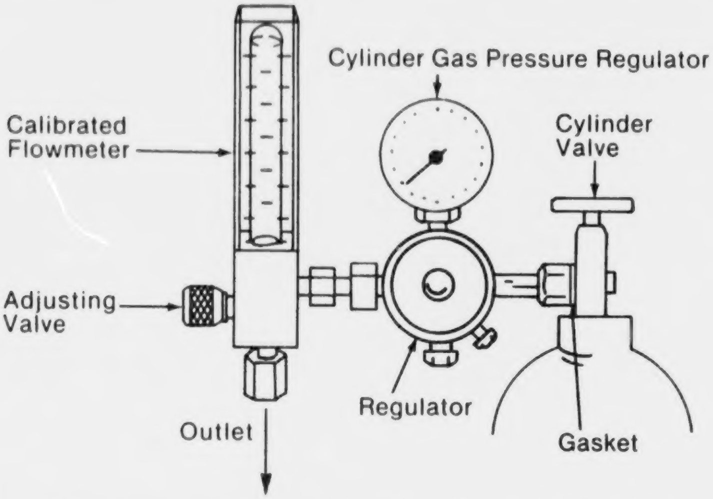
☐ 3. Crack the cylinder valve slightly to clear the cylinder valve fitting.

☐ 4. Check the gasket and then attach the flow meter regulator to the cylinder valve.

☐ 5. Tighten the regulator fitting nut with a wrench, but do not overtighten.

Job Sheet 2

☐ 6. Make sure the flow meter adjusting valve is off, and if it is not, turn it clockwise until it is tight.


Cylinder Gas Pressure Regulator
Calibrated Flowmeter
Cylinder Valve
Adjusting Valve
Regulator
Outlet
Gasket

☐ 7. Open the gas cylinder valve all the way so that it will back seat against the top of the valve.

☐ 8. Set up and turn on the GMAW machine.

☐ 9. Turn the wire feed as low as it will go and press the gun trigger switch.

☐ 10. Turn the flow meter adjusting screw counterclockwise to make adjustment for the desired Cfh.

☐ 11. Use the very top of the ball as the reference point for adjusting Cfh.

☐ 12. Release gun trigger switch.

☐ 13. Have your instructor check your work.

☐ 14. Shut down and secure equipment.

☐ 15. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 3—Set Up GMAW Equipment for Short-Circuit Transfer on Mild Steel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Flow meter and regulator setup	______
Amp/ipm adjustment	______
Proper electrode extension	______
Test bead evaluation	______
Proper shut down procedure	______

A. Tools and materials

GMAW machine and accessories
Selected shielding gas
Selected wire
Personal safety clothing and safety glasses
Adjustable wrench
Selected mild or stainless steel

B. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas and adjust the flow rate as previously outlined.

☐ 2. Attach ground clamps to the workpiece.

☐ 3. Turn the machine on.

☐ 4. Turn the wire feed power on, if applicable.

☐ 5. Adjust voltage and wire feed speed to approximate settings for wire size and plate thickness.

☐ 6. Place a piece of scrap metal on the work table so that it is behind you as you face the meters on the machine.

Job Sheet 3

☐ 7. Place the nozzle of the gun on the piece of scrap metal so the correct electrode extension can be determined and maintained.

☐ 8. Face the machine meters, keep the gun behind you, and press the trigger to create an arc.

☐ 9. Observe voltage and amp meters quickly, and make a mental note of their readings.

Note: If this step is too difficult, ask another student to help you.

☐ 10. Release the trigger to break the arc.

☐ 11. Make adjustments as needed to correct voltage and amperage.

☐ 12. Run a test bead on the piece of scrap metal, and listen carefully for a sound like that of bacon frying on a slightly too hot fire.

☐ 13. Release the trigger and inspect the bead.

☐ 14. Lower voltage or increase wire feed speed if the bead is flat and wide.

☐ 15. Raise voltage and decrease wire wire feed speed if the bead is narrow and humpy.

☐ 16. Increase inductance or slope, or both, if there is excess spatter.

☐ 17. Correct the gun angle, electrode extension, or travel speed if the bead has poor shape or undercutting.

☐ 18. Run another test bead to achieve proper setting and get a good bead appearance.

☐ 19. Inspect your test bead for good penetration, good fusion, and uniform width with minimum spatter.

☐ 20. Have your instructor check your work.

☐ 21. Set wire speed feed to zero.

☐ 22. Turn off gas supply.

☐ 23. Depress gun trigger to relieve shielding gas pressure.

☐ 24. Allow ball in flow meter to return to zero.

☐ 25. Turn off feed control power switch, if applicable.

Job Sheet 3

☐ 26. Turn off welding machine power supply.

☐ 27. Set voltage at zero.

☐ 28. Store gun, cable assembly, and ground clamp in proper storage.

☐ 29. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
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Job Sheet 4—Prepare Mild Steel for GMAW

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Safe use of proper tools	______
Workpiece preparation	______
Joint preparation	______

A. Tools and materials

Mild steel as selected by instructor
Joint design as specified by instructor
Portable grinder and sanding equipment
Pliers and clamps
Clean shop rags
Wire brush
Personal safety clothing and safety glasses

B. Procedure

☐ 1. Secure the workpiece with pliers or clamps.

☐ 2. Remove mill scale, rust, dirt, and paint from all surfaces with a portable sander.

☐ 3. Grind edges of joints to specifications.

☐ 4. Wire brush, if required.

☐ 5. Have your instructor check your work.

☐ 6. Return tools and materials to proper storage.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
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Job Sheet 5—Use Short-Circuit Transfer to Lay Stringer Beads on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

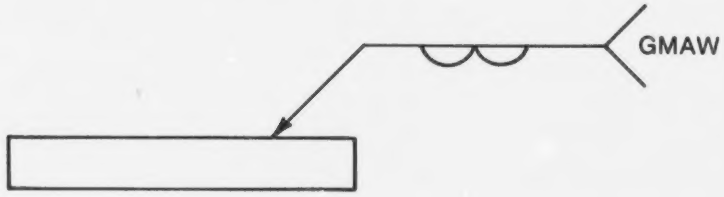
Evaluation criteria	**Rating**
Equipment setup	______
Electrical adjustments	______
Electrode extension	______
Welding technique	______
Cleaning	______
Inspection of bead	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Mild steel as selected by instructor
Wire-cutting pliers and wire brush
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 5

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: Flat
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

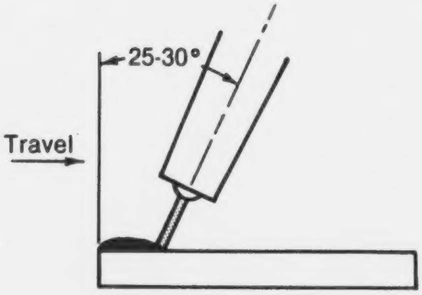
☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust flow rate.

☐ 2. Complete equipment setup as previously outlined.

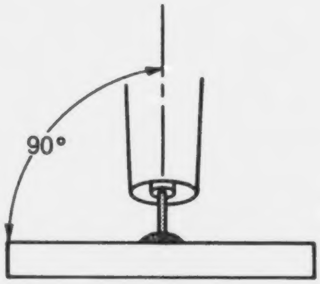
☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Position plate on work table.

☐ 5. Move gun down to plate and check gun angle and electrode extension.



Side View



Front View

Job Sheet 5

☐ 6. Squeeze gun trigger and use a push or pull technique to lay the bead from left to right if right-handed, and right to left if left-handed.

Note: The nozzles for GMAW guns are large enough that a good view of the weld zone will require that you position yourself so you can see to maintain the correct gun angle and electrode extension.

☐ 7. Weld the full length of the plate and crater and fill to complete the bead.

☐ 8. Release gun trigger.

☐ 9. Place gun in a safe place.

☐ 10. Clean to specifications.

☐ 11. Inspect for good penetration and fusion, uniform bead width and appearance, and defects such as excessive spatter and undercutting.

☐ 12. Have your instructor check your work.

☐ 13. Continue making practice beads as directed by your instructor.

☐ 14. Inspect all beads.

☐ 15. Have your instructor check your work.

☐ 16. Check in tools and materials clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
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Job Sheet 6—Use Short-Circuit Transfer to Build a Pad on Mild Steel in the Flat Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

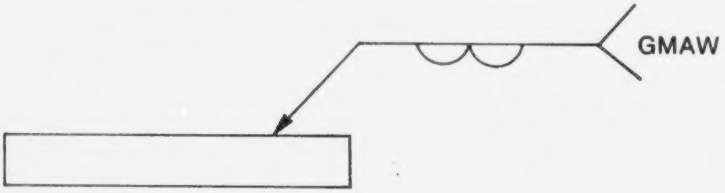
Evaluation criteria	Rating
Equipment setup	
Electrical adjustments	
Electrode extension	
Welding technique	
Cleaning	
Inspection	

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Mild steel as selected by instructor
Wire-cutting pliers and wire brush
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 6

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: Flat
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

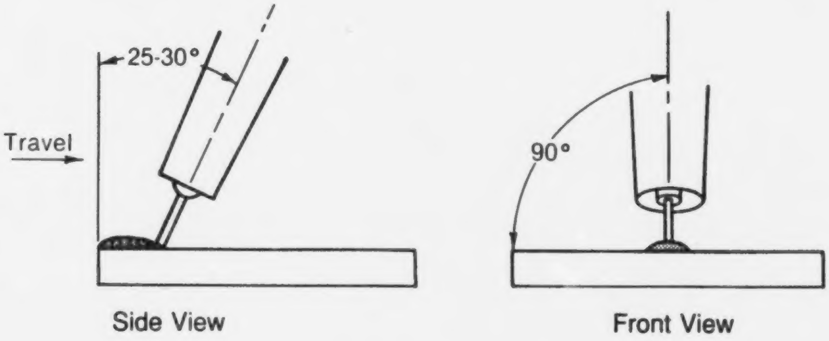
☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust flow rate.

☐ 2. Complete equipment setup as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Position plate on work table.

☐ 5. Move gun down to plate and check gun angle and electrode extension.



Side View

Front View

Job Sheet 6

☐ 6. Squeeze gun trigger and use a push or pull technique to lay the bead from left to right if right-handed, and right to left if left-handed.

Note: The nozzles for GMAW guns are large enough that a good view of the weld zone will require that you position yourself so you can see to maintain the correct gun angle and electrode extension.

☐ 7. Weld the full length of the plate and crater and fill to complete the bead.

☐ 8. Release gun trigger.

☐ 9. Place gun in a safe place.

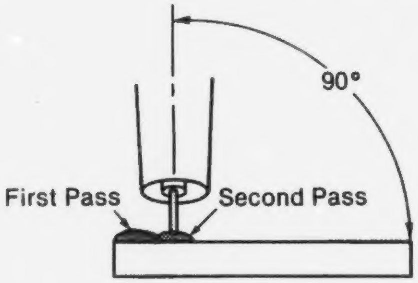
☐ 10. Clean to specifications.

☐ 11. Inspect for good penetration and fusion, uniform bead width and appearance, and defects such as excessive spatter and undercutting.

☐ 12. Have your instructor check your work.

☐ 13. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 14. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.



Front View

☐ 15. Pull the trigger and complete second bead.

☐ 16. Clean and inspect each bead.

Job Sheet 6

☐ 17. Have your instructor check your finished pad.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ______________________________________

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GMAW Equipment, Applications, and Techniques
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Job Sheet 7—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

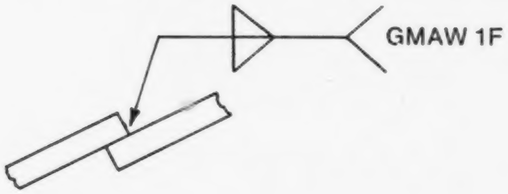
Evaluation criteria	**Rating**
Equipment setup	______
Electrical adjustments	______
Electrode extension	______
Welding technique	______
Cleaning	______
Break test	______
Inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Mild steel as selected by instructor
Wire-cutting pliers and wire brush
Bench vise and hammer
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 7

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Break

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust flow rate.

☐ 2. Complete equipment setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

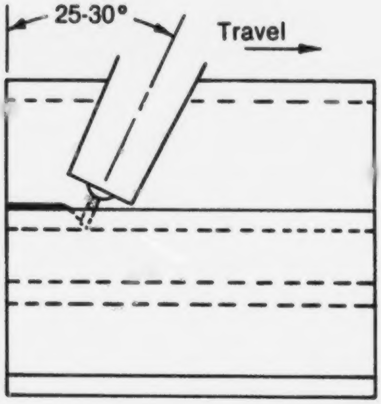
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

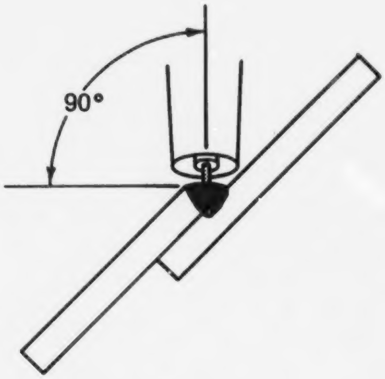
☐ 6. Position plates in correct welding position.

Job Sheet 7

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to the end of the weld, and put gun in a safe place.

☐ 10. Clean joint with a wire brush as specified.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to a vise and conduct a break test as demonstrated in Job Sheet 8.

☐ 14. Inspect break for good penetration and fusion.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld the other side of the joint, if required by your instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to the vise and conduct another break test.

Job Sheet 7

☐ 20. Inspect break for good penetration and fusion.

☐ 21. Have your instructor check your work.

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 8—Break Test a Single-Pass Lap Joint

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Positioning of test joint in vise	______
Execution of break	______
Inspection	______

A. Tools and materials

Bench vise and fitter's hammer
Pliers
Welded lap joint from Job Sheet 7
Personal safety clothing and safety glasses

B. Procedure

☐ 1. Position the lap joint so that the joint runs parallel with and just above the jaws of the vise, and tighten vise.

☐ 2. Strike the plate that is not secured in the vise in a direction that will cause it to break away from the plate that is secured.

Job Sheet 8

☐ 3. Inspect break to make sure the line of the break is centered down the joint, and also inspect for good penetration and fusion or any defects.

☐ 4. Have your instructor check your work.

☐ 5. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 9—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

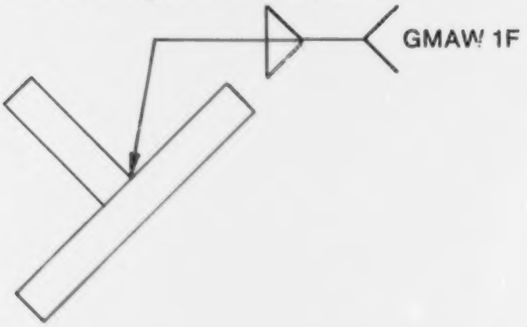
Evaluation criteria	Rating
Equipment setup	______
Electrical Adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 9

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

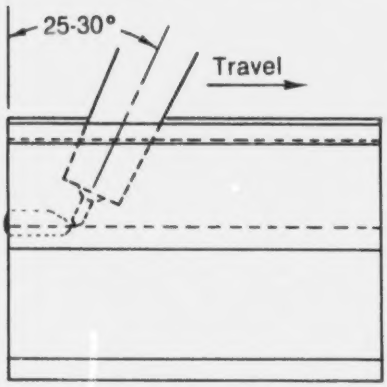
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

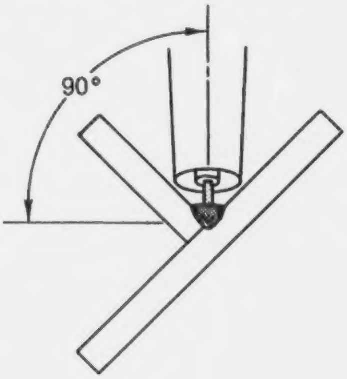
☐ 6. Position plates in correct welding position.

Job Sheet 9

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

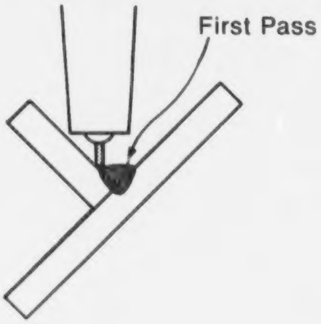
☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Check electrode extension for start of second bead, and trim as required, but do not arc excess wire off on the side of the work table.

☐ 13. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.



☐ 14. Pull the trigger and complete second bead.

Job Sheet 9

☐ 15. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal.

☐ 16. Have your instructor check your work.

☐ 17. Continue with additional beads as directed by your instructor.

☐ 18. Have your instructor check your work.

☐ 19. Repeat procedure for the other side of the joint, if required by your instructor.

☐ 20. Have your instructor check your work.

☐ 21. Shut down and secure equipment.

☐ 22. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 10—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

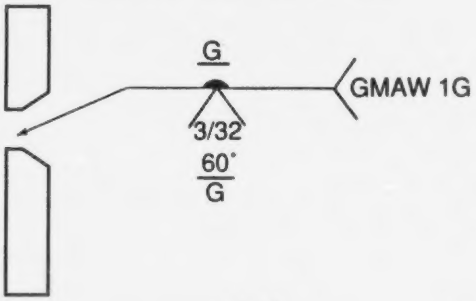
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding and crater and fill technique, first pass	______
Welding and crater and fill technique, second pass	______
Cleaning and inspection	______
Bend test	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Bend test machine
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 10

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Bend

C. Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1/16″ to 3/32″ root face.

☐ 2. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 3. Complete setup for short-circuit transfer as previously outlined.

☐ 4. Adjust controls for plate thickness and wire diameter.

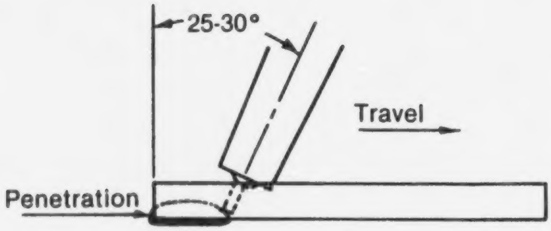
☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Position plates upside down on work table and tack both ends of joint, leaving a 3/32″ opening, although opening will vary with metal thickness.

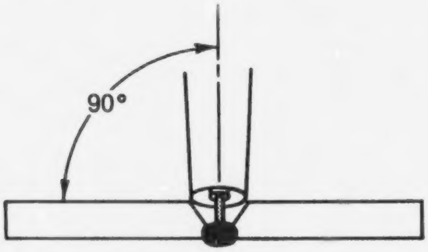
☐ 7. Turn plates over and position for joint weld as specified.

Job Sheet 10

☐ 8. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 9. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

☐ 10. Crater and fill to end the weld, and put gun in safe place.

☐ 11. Clean join with wire brush as required.

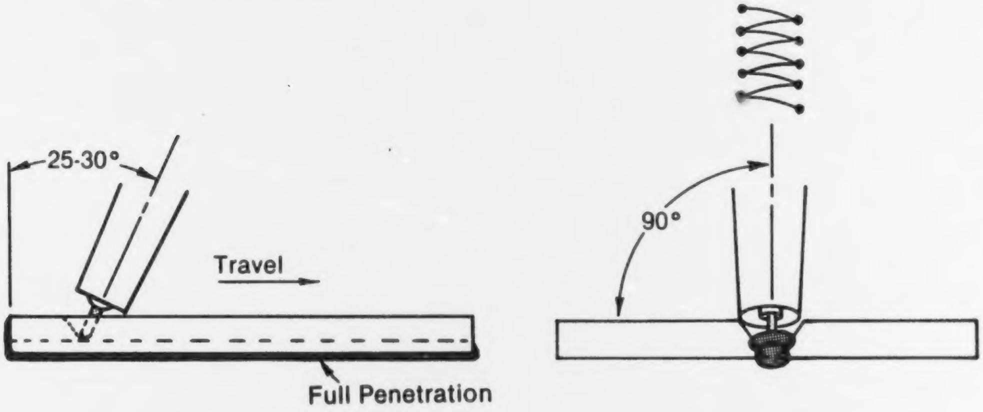
☐ 12. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 13. Have your instructor check your work.

☐ 14. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

Job Sheet 10

☐ 15. Reposition gun and use a weaving technique to lay a second pass over the first bead.



Side View　　Front View

☐ 16. Crater and fill to end the weld, and put gun in safe place.

☐ 17. Clean and inspect second bead.

☐ 18. Have your instructor check your work.

☐ 19. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal.

☐ 20. Clean and inspect the final fill bead.

☐ 21. Have your instructor check your work.

☐ 22. Check electrode extension for start of cap bead, and trim wire as required.

☐ 23. Reposition gun and use a weaving technique to place the cap pass on the joint.

☐ 24. Clean and inspect cap pass, and put gun in safe place.

☐ 25. Prepare specimens for bend test as outlined in Job Sheet 11.

☐ 26. Complete bend test.

☐ 27. Have your instructor check your work.

☐ 28. Shut down and secure equipment.

Job Sheet 10

☐ 29. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 11—Bend Test a Welded V-Groove Butt Joint

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Preparation of test specimen	______
Root bend procedure	______
Face bend procedure	______
Final procedure evaluation	______

A. Tools and materials

Oxyacetylene cutting unit and cutting goggles
Portable hand grinder
File and pliers
Groove weld test plate, ⅜″ thickness
Straightedge and soapstone
Bend test machine
Personal safety clothing and safety glasses

B. Procedure

☐ 1. Check the work area to make sure it is free of flammable materials, and note the location of the nearest fire extinguisher.

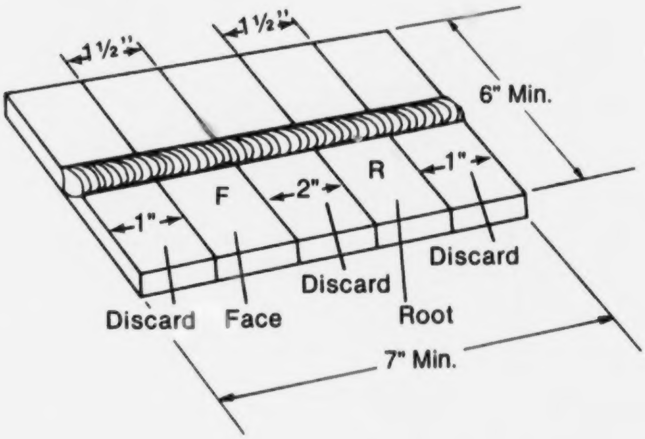
☐ 2. Check the work area for proper ventilation so you can safely use oxyacetylene cutting equipment.

☐ 3. Place the groove weld test plate on a work table in front of you so that measuring and marking can be accomplished accurately.

☐ 4. Use the straightedge and soapstone to mark off bend specimens for a face bend and a root bend.

Job Sheet 11

☐ 5. Mark the face and root bend specimens with an F and an R as indicated in the following illustration.



Note: The face and root bend dimensions shown in the illustration above are in accordance with AWS specifications for welder certification. For training purposes, specimens may be reduced to a total length of 5" with the 1½" specimens cut left and right of center.

☐ 6. Set up oxyacetylene equipment, light and adjust cutting flame and cut the specimens perpendicular to the weld as marked.

☐ 7. Turn off torch and shut down cutting unit.

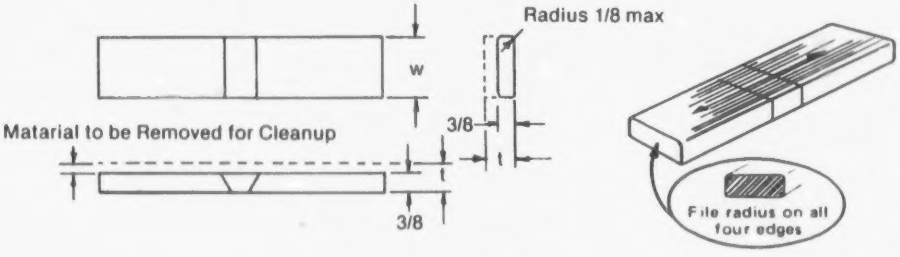
☐ 8. Permit specimens to air cool, but do not quench them in water or they will be unsuitable for testing.

Job Sheet 11

☐ 9. Take cooled specimens one at a time, secure in a vise, and use a portable grinder to grind to the following specifications:

a. Face bend specimen for a plunger-type tester should be a minimum of 6″ long, 1½″ wide and so ground that both the root and face of the weld are flush with the surface of the specimen.

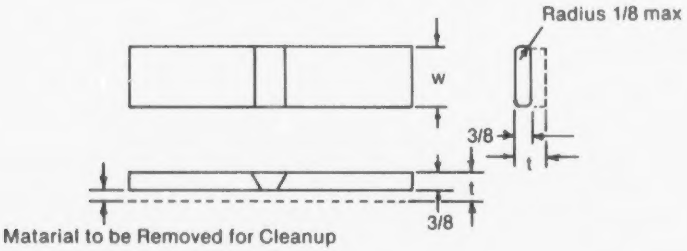
Note: For a wraparound-type tester, a longer specimen will probably be required.


Radius 1/8 max
w
3/8
t
Matarial to be Removed for Cleanup
t
3/8
File radius on all four edges

Courtesy Lincoln Electric Company

b. Root bend specimen for a plunger-type tester should be a minimum 6″ long, 1½″ wide and so ground that both the root and face of the weld are flush with the surface of the specimen.

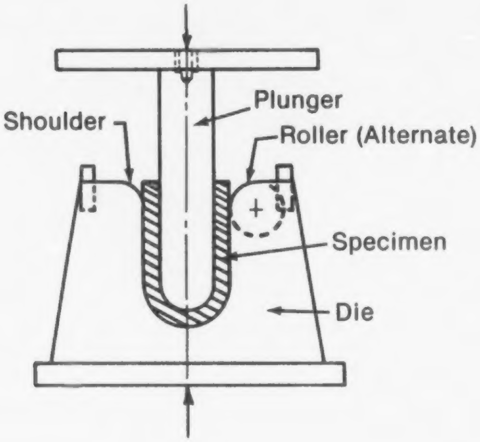
Note: For a wraparound-type tester, a longer specimen will probably be required.

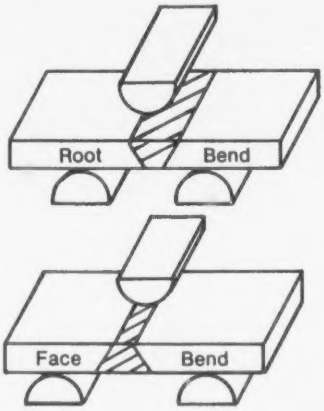

Radius 1/8 max
w
3/8
t
t
3/8
Matarial to be Removed for Cleanup

Courtesy Lincoln Electric Company

☐ 10. Grind or file the corners of both specimens so that they have a ⅛″ radius.

☐ 11. Take specimens to plunger-type tester and make bends according to the following procedure:





a. Place the face bend specimen on the die member of the jig with the face of the weld pointing into the die so that the plunge is on the root side of the weld.

b. Actuate the plunger to force the specimen between the plunger and the die until it is formed into a U shape.

Caution: Always wear safety glasses when conducting bend tests.

c. Release pressure on plunger to release the specimen from the die.

☐ 12. Repeat the testing procedure for the root bend, but reverse the root and face of the weld as you place it on the die.

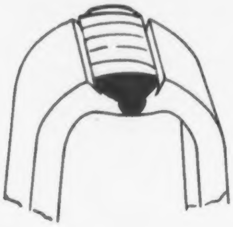
☐ 13. Inspect test specimens according to the following procedure:

a. Examine convex surface of both specimens for cracks or other open defects.

b. Check root bend to determine if weld has complete penetration through the joint.

Job Sheet 11

c. Check face bend to determine if there is complete fusion of the beveled edges with the weld.



☐ 14. Have your instructor check your bend test.

☐ 15. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 12—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

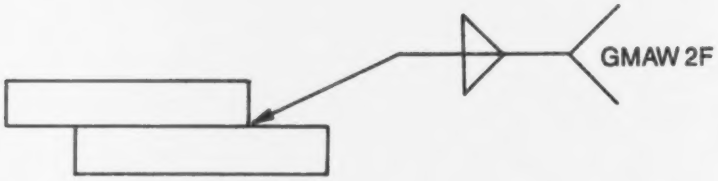
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Break test	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Vise and hammer
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 12

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Break

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

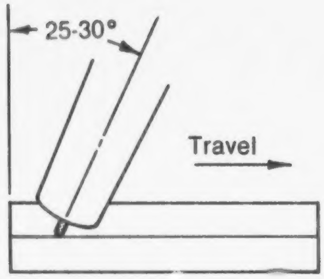
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

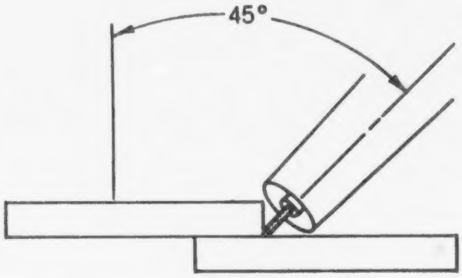
☐ 6. Position plates in correct welding position.

Job Sheet 12

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to a vise and conduct a break test.

☐ 14. Inspect break for good penetration and fusion.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld the other side of the joint, if required by your instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to the vise and conduct another break test.

☐ 20. Inspect bread for good penetration and fusion.

☐ 21. Have your instructor check your work.

Job Sheet 12

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ____

GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 13—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

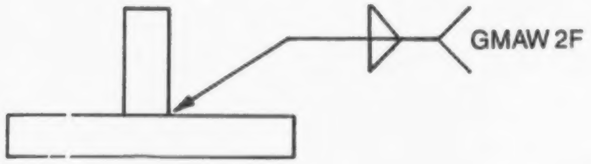
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 13

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

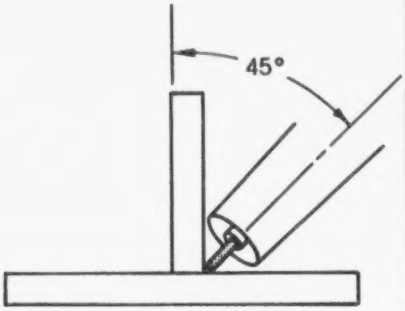
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

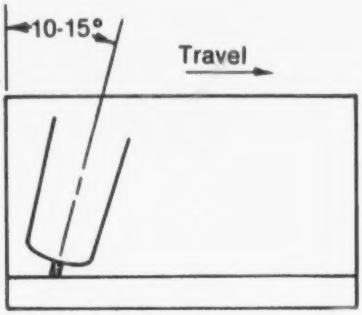
☐ 6. Position plates in correct welding position.

Job Sheet 13

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

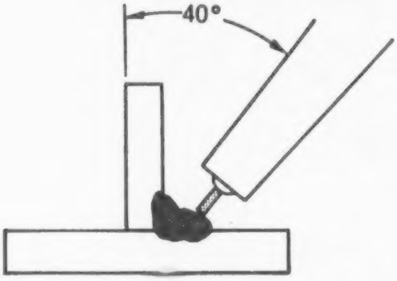
☐ 9. Crater and fill to end the weld, and put gun in safe place.

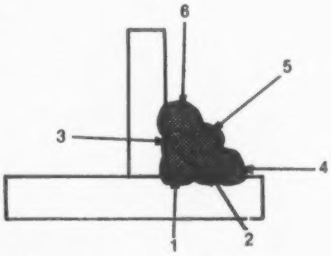
☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 13. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.





☐ 14. Pull the trigger and complete second bead.

Job Sheet 13

☐ 15. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal.

☐ 16. Have instructor check your work.

☐ 17. Continue with additional beads as directed by your instructor.

☐ 18. Have your instructor check your work.

☐ 19. Repeat the procedure for the other side of the joint, if directed by your instructor.

☐ 20. Have your instructor check your work.

☐ 21. Shut down and secure equipment.

☐ 22. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 14—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

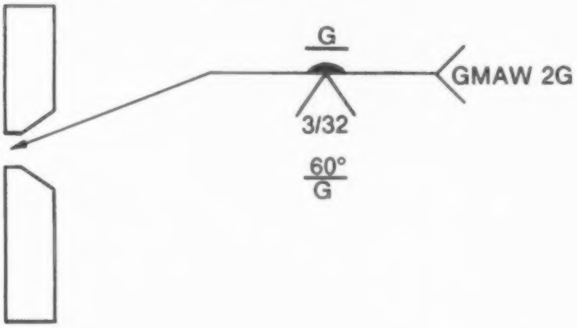
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Bend test	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Bend test machine
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 14

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Bend

C. Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a $\frac{1}{16}$″ to $\frac{3}{32}$″ root face.

☐ 2. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 3. Complete setup for short-circuit transfer as previously outlined.

☐ 4. Adjust controls for plate thickness and wire diameter.

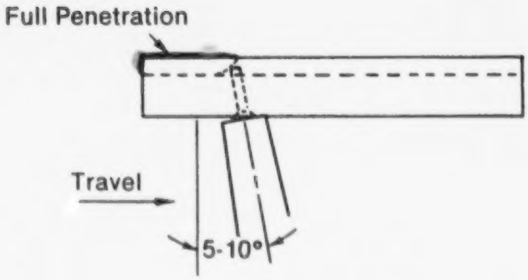
☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Position plates upside down on work table and tack both ends of joint, leaving a $\frac{3}{32}$″ root opening, although opening will vary with metal thickness.

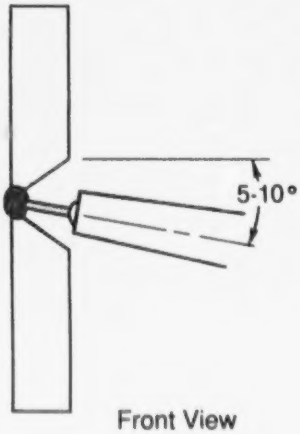
☐ 7. Turn plates over and position for joint weld as specified.

Job Sheet 14

☐ 8. Position gun at correct angle to joint and check electrode extension.



Top View



Front View

☐ 9. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 10. Crater and fill to end the weld, and put gun in safe place.

☐ 11. Clean joint with wire brush as required.

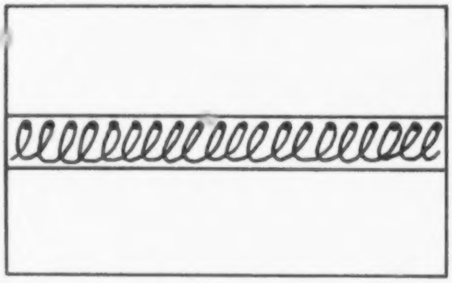
☐ 12. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

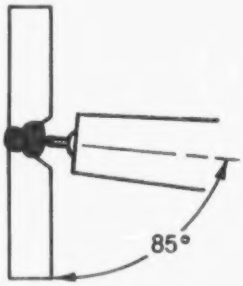
☐ 13. Have your instructor check your work.

☐ 14. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 15. Reposition gun and use a weaving technique to lay a second pass over the first bead.

(Pause at Dots)





Job Sheet 14

☐ 16. Crater and fill to end the weld, and put gun in safe place.

☐ 17. Clean and inspect second bead.

☐ 18. Have your instructor check your work.

☐ 19. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal.

☐ 20. Clean and inspect final fill bead.

☐ 21. Have your instructor check your work.

☐ 22. Check electrode extension for start of cap bead, and trim wire as required.

☐ 23. Reposition gun and use a weaving technique to place the cap pass on the joint.

☐ 24. Clean and inspect cap pass, and put gun in safe place.

☐ 25. Prepare specimens for bend test as previously outlined.

☐ 26. Complete bend test

☐ 27. Have your instructor check your work.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 15—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

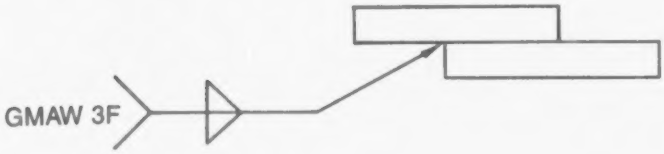
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Break test	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Vise and hammer
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 15

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical up
9. Technique: Push or pull
10. Cleaning: Brush
11. Inspection: Visual
12. Testing: Break

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

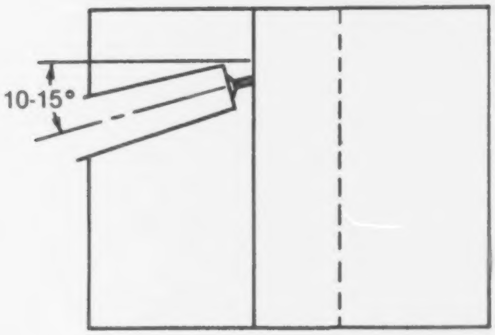
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

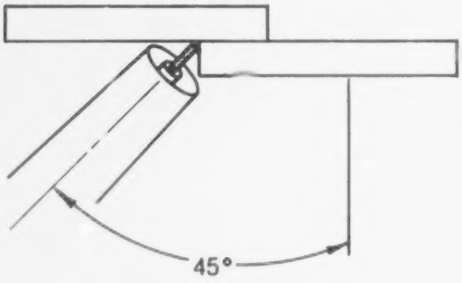
☐ 6. Position plates in correct welding position.

Job Sheet 15

☐ 7. Position gun at correct angle to joint and check electrode extension.



Front View



Top View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to vise and conduct a break test.

☐ 14. Inspect break for good penetration and fusion or defects.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld other side of joint.

☐ 17. Clean and visually inspect joint.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to vise and conduct another break test.

☐ 20. Inspect break for good penetration and fusion or defects.

☐ 21. Have your instructor check your work.

Job Sheet 15

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 16—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

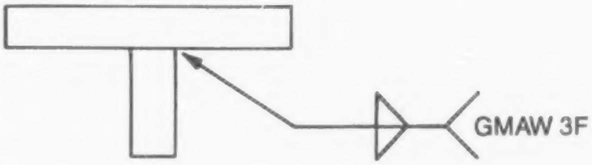
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 16

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical up
9. Technique: Push or pull
10. Cleaning: Brush
11. Inspection: Visual
12. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

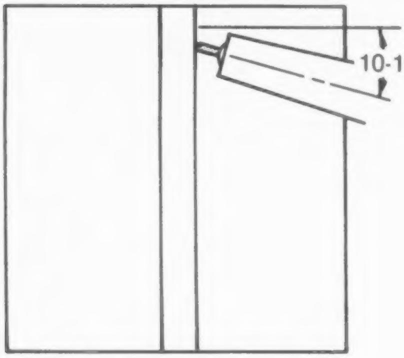
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

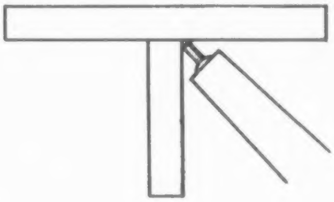
☐ 6. Position plates in correct welding position.

Job Sheet 16

☐ 7. Position gun at correct angle to joint and check electrode extension.



Front View



Top View

☐ 8. Squeeze gun trigger and use push or pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

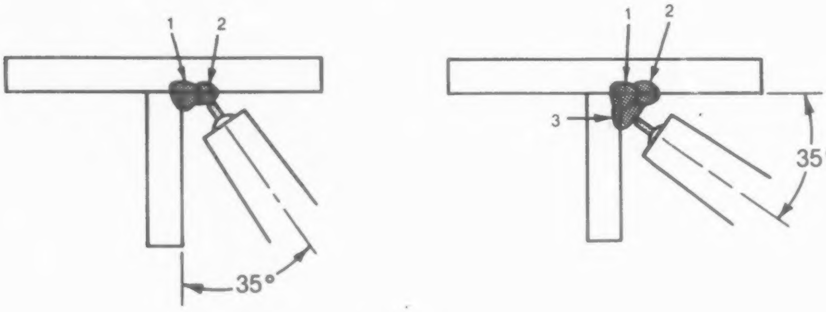
☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 13. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.



Top Views

Job Sheet 16

☐ 14. Pull the trigger and complete second bead.

☐ 15. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal.

☐ 16. Have instructor check your work.

☐ 17. Continue with additional beads as directed by your instructor.

☐ 18. Have your instructor check your work.

☐ 19. Repeat the procedure for the other side of the joint, if directed by your instructor.

☐ 20. Have your instructor check your work.

☐ 21. Shut down and secure equipment.

☐ 22. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 17—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

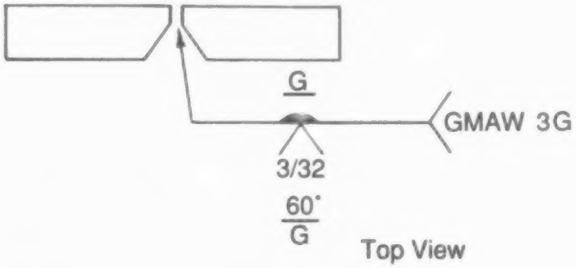
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Bend test	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Bend test machine
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 17

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3G
8. Direction of welding: Vertical up
9. Technique: Weave
10. Cleaning: Brush
11. Inspection: Visual
12. Testing: Bend

C. Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1/16″ to 3/32″ root face.

☐ 2. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 3. Complete setup for short-circuit transfer as previously outlined.

☐ 4. Adjust controls for plate thickness and wire diameter.

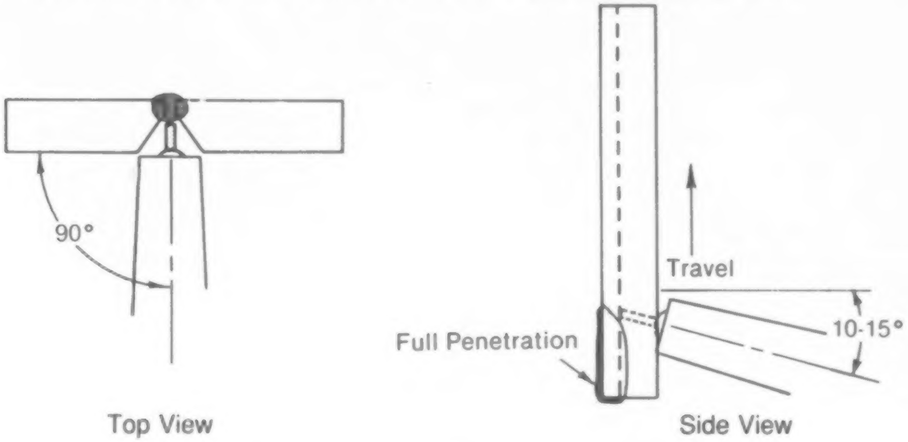
☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Position plates upside down on work table and tack both ends of joint, leaving a 3/32″ opening, although opening will vary with metal thickness.

☐ 7. Turn plates over and position for joint weld as specified.

Job Sheet 17

☐ 8. Position gun at correct angle to joint and check electrode extension.



☐ 9. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

☐ 10. Crater and fill to end the weld, and put gun in safe place.

☐ 11. Clean join with wire brush as required.

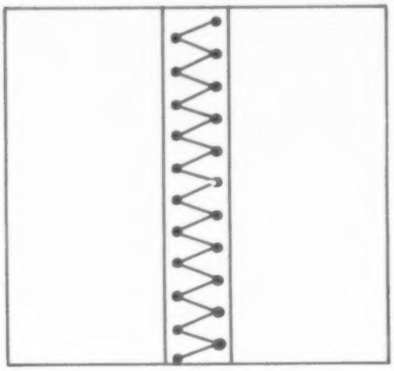
☐ 12. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

☐ 13. Have your instructor check your work.

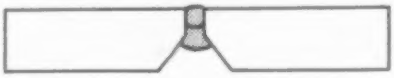
☐ 14. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

Job Sheet 17

☐ 15. Reposition gun and use a weaving technique to lay a second pass over the first bead.



(Pause at Dots)



Top View

☐ 16. Crater and fill to end the weld, and put gun in safe place.

☐ 17. Clean and inspect second bead.

☐ 18. Have your instructor check your work.

☐ 19. Continue running weave bead until enough beads have been laid down to fill the joint even with the surface of the base metal.

☐ 20. Clean and inspect the final fill bead.

☐ 21. Have your instructor check your work.

☐ 22. Check electrode extension for start of cap bead, and trim wire as required.

☐ 23. Reposition gun and use a weaving technique to place the cap pass on the joint.

☐ 24. Clean and inspect cap pass, and put gun in safe place.

☐ 25. Prepare specimens for bend test as previously outlined.

☐ 26. Complete bend test.

☐ 27. Have your instructor check your work.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 18—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

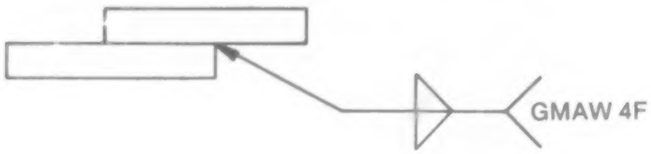
Evaluation criteria	Rating
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Break test	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 18

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 4F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Break

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

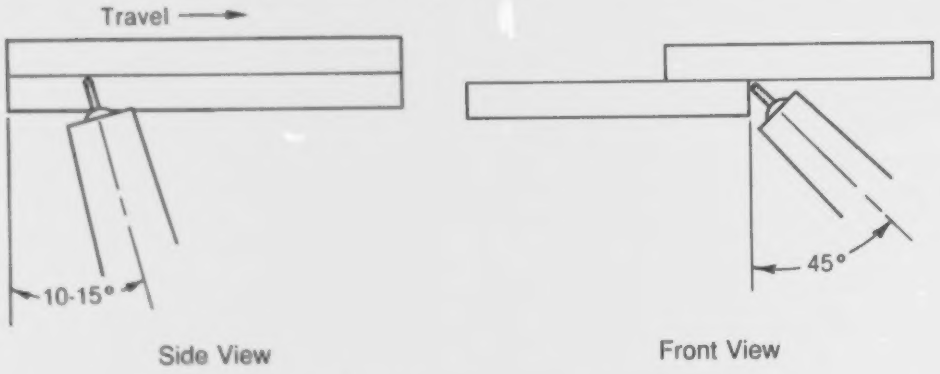
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in correct welding position.

Job Sheet 18

☐ 7. Position gun at correct angle to joint and check electrode extension.



☐ 8. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to vise and conduct a break test.

☐ 14. Inspect break for good penetration and fusion, and for defects.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld other side of joint, if required by your instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to vise and conduct another break test.

☐ 20. Inspect bread for good penetration and fusion, and for defects.

☐ 21. Have your instructor check your work.

Job Sheet 18

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 19—Use Short-Circuit Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

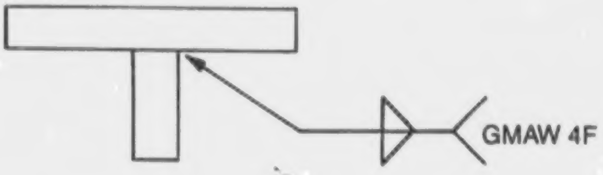
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor

B. Specifications

1. Joint design and weld symbol:



Job Sheet 19

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 4G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

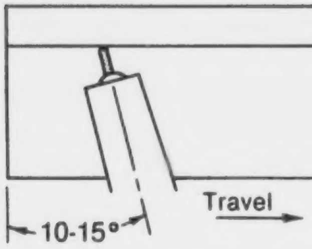
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

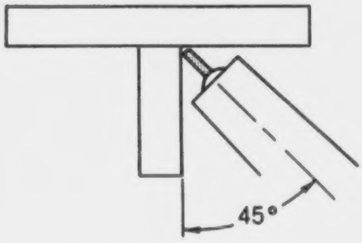
☐ 6. Position plates in correct welding position.

Job Sheet 19

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

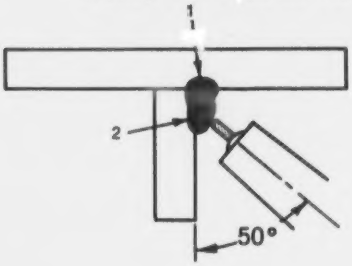
☐ 9. Crater and fill to end the weld, and put gun in safe place.

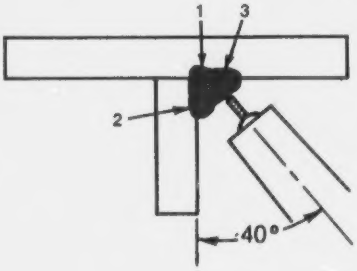
☐ 10. Clean weld with wire brush as required.

☐ 11. Inspect weld visually.

☐ 12. Check electrode extension for start of second bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 13. Start second bead by repositioning gun angle so that second bead till overlap first bead as indicated.





☐ 14. Pull the trigger and complete second bead.

☐ 15. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal.

Job Sheet 19

☐ 16. Have your instructor check your work.

☐ 17. Continue with additional beads as directed by your instructor.

☐ 18. Have your instructor check your work.

☐ 19. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 20. Have your instructor check your work.

☐ 21. Shut down and secure equipment.

☐ 22. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 20—Use Short-Circuit Transfer to Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

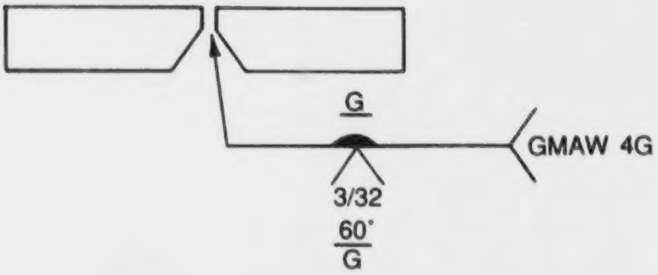
Evaluation criteria	Rating
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Bend test	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Bend test machine

B. Specifications

1. Joint design and weld symbol:



Job Sheet 20

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 4G
8. Technique: Weave
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Bend

C. Procedure

☐ 1. Prepare plates with 30° bevels and grind edges to leave a 1⁄16″ to 3⁄32″ root face.

☐ 2. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 3. Complete setup for short-circuit transfer as previously outlined.

☐ 4. Adjust controls for plate thickness and wire diameter.

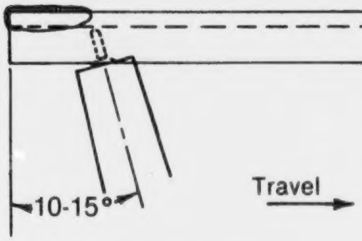
☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Position plates upside down on work table and tack both ends of joint, leaving a 3⁄32″ opening, although opening will very with metal thickness.

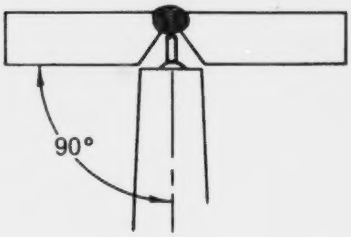
☐ 7. Turn plates over and position for joint weld as specified.

Job Sheet 20

☐ 8. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 9. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

☐ 10. Crater and fill to end the weld, and put gun in safe place.

☐ 11. Clean joint with wire brush as required.

☐ 12. Inspect joint visually front and back for complete penetration, good fusion, uniform bead width, and minimum spatter.

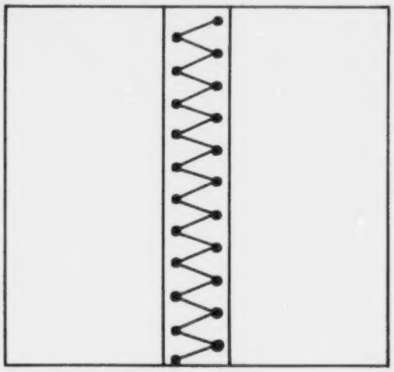
☐ 13. Have your instructor check your work.

☐ 14. Check electrode extension for start of fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

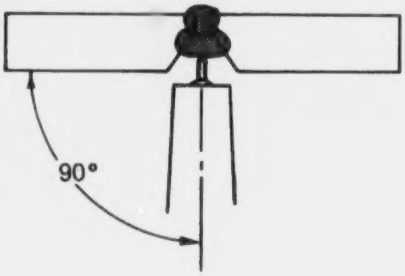
Job Sheet 20

☐ 15. Reposition gun and use a weaving technique to lay a second pass over the first bead.

(Pause at Dots)



Bottom View



Front View

☐ 16. Crater and fill to end the weld, and put gun in safe place.

☐ 17. Clean and inspect second bead.

☐ 18. Have your instructor check your work.

☐ 19. Continue running weave bead until enough beads have been laid down to fill the join even with the surface of the base metal.

☐ 20. Clean and inspect the final fill bead.

☐ 21. Have your instructor check your work.

☐ 22. Check electrode extension for start of cap bead, and trim wire as required.

☐ 23. Reposition gun and use a weaving technique to place the cap pass on the joint.

☐ 24. Clean and inspect cap pass, and put gun in safe place.

☐ 25. Prepare specimens for bend test as previously outlined.

☐ 26. Complete bend test

☐ 27. Have your instructor check your work.

☐ 28. Shut down and secure equipment.

Job Sheet 20

☐ 29. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 21—Set Up GMAW Equipment for Spray Transfer with Mild Steel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup	______
Initial adjustments	______
Test bead and evaluation	______
Final adjustments	______
Equipment shutdown	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Adjustable wrench
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol: N/A
2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: Flat

Job Sheet 21

8. Direction of welding: Per instructor

9. Technique: Pull

10. Cleaning: Brush

11. Inspection: Visual

12. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Attach ground clamp to workpiece.

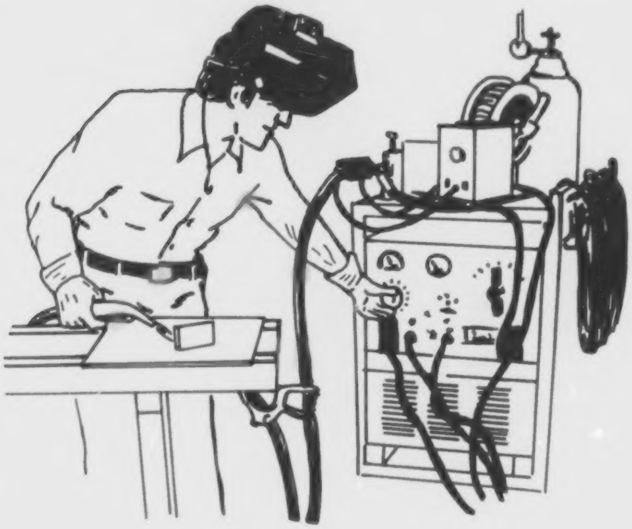
☐ 3. Turn machine on.

☐ 4. Adjust voltage and amperage to approximate settings for wire size and plate thickness, and remember that these settings are higher for spray transfer than they are for short-circuit transfer.

Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

Job Sheet 21

☐ 5. Place a piece of scrap metal on the work table so that it is behind you and you are facing the meters on the machine.



☐ 6. Turn wire feed power on.

☐ 7. Place nozzle of the gun on the piece of scrap metal so that the correct electrode extension can be maintained, and remember that electrode extension should be ½″ to ¾″ for spray transfer.

☐ 8. Face the machine meters, keep the gun behind you, and press the trigger to create an arc.

☐ 9. Observe the voltage and amp meters quickly, and make a mental note of meter readings.

Note: If the previous step is too difficult, ask another student to assist you.

☐ 10. Release the trigger to break the arc.

☐ 11. Make adjustments as needed to correct voltage and amperage.

☐ 12. Run a test bead on the piece of scrap metal and listen carefully for a sound that is louder and more intense than the sound heard with the short-circuit transfer, and look for a brighter arc caused by higher amperage.

Job Sheet 21

☐ 13. Release the trigger and inspect the bead and make corrections as follows:

  a. If there is poor bead shape and undercutting, lower voltage and correct gun angle, electrode extension, and gas mixture.

  b. If there is excess spatter, increase inductance.

  c. If the bead is narrow and humpy, raise voltage and decrease wire feed speed.

  d. If the bead is flat and wide, lower voltage or increase wire feed speed.

☐ 14. Repeat procedure until settings are proper and bead has good appearance.

☐ 15. Release trigger, put gun in safe place, and inspect your bead for good penetration, good fusion, and uniform bead width with minimum spatter.

☐ 16. Have your instructor check your work.

☐ 17. Set wire speed feed to zero.

☐ 18. Turn off gas supply.

☐ 19. Depress gun trigger to relieve shielding gas pressure.

☐ 20. Allow ball in flow meter to return to zero.

☐ 21. Turn off feed control power switch, if applicable.

☐ 22. Turn off welding machine power supply.

☐ 23. Set voltage at zero.

☐ 24. Store gun, cable assembly, and ground clamp in safe place.

☐ 25. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 22—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

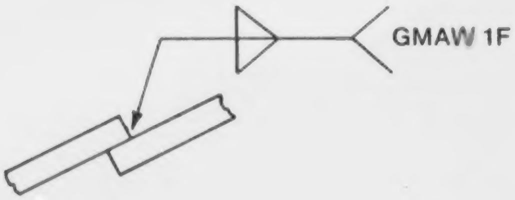
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Break test	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Vise and hammer
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 22

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Break

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

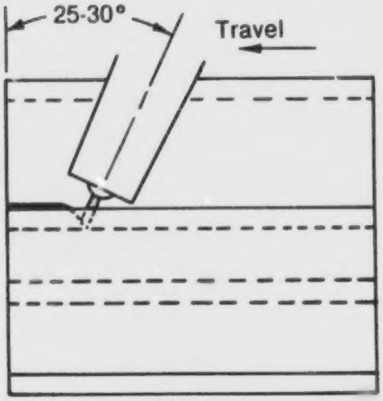
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joint.

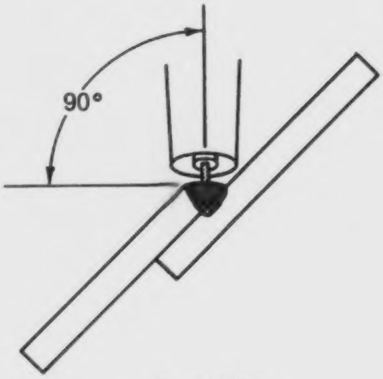
☐ 6. Position plates in correct welding position.

Job Sheet 22

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to vise and conduct a break test.

☐ 14. Inspect break for good penetration and fusion.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld other side of joint, if required by your instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to vise and conduct another break test.

☐ 20. Inspect break for good penetration and fusion.

Job Sheet 22

☐ 21. Have your instructor check your work.

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 23—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position

Name ________________________ Attempt Number ________

Date ________________________ Overall Rating ________

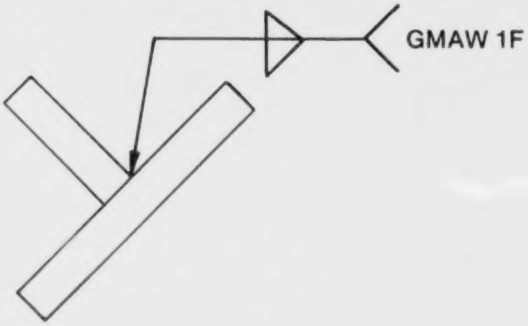
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 23

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap metal and make required adjustments.

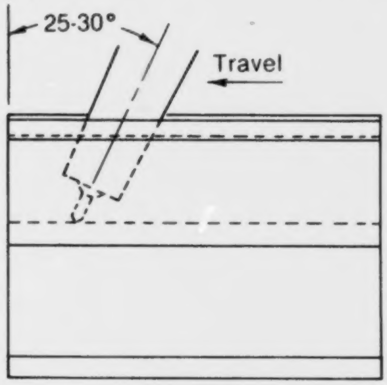
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

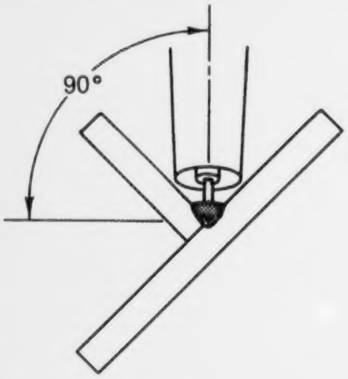
☐ 6. Position plates in correct welding position.

Job Sheet 23

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

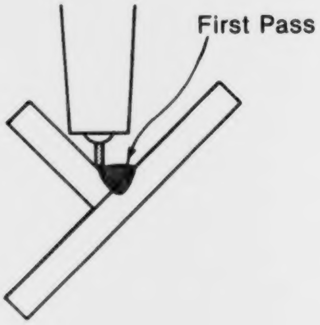
☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Check electrode extension for start of second bead, and trim as required, but do not arc excess wire off on the side of the work table.

☐ 13. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.



☐ 14. Pull the trigger and complete second bead.

Job Sheet 23

☐ 15. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal.

☐ 16. Have your instructor check your work.

☐ 17. Continue with additional beads as directed by your instructor.

☐ 18. Have your instructor check your work.

☐ 19. Repeat procedure for the other side of the joint, if required by your instructor.

☐ 20. Have your instructor check your work.

☐ 21. Shut down and secure equipment.

☐ 22. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 24—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

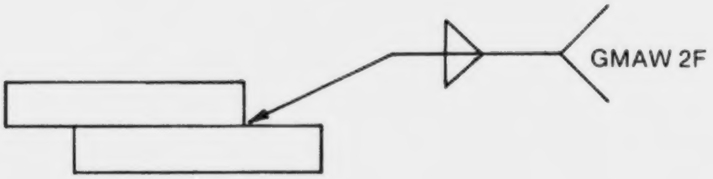
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Break test	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Vise and hammer
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 24

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: Break

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap metal and make required adjustments.

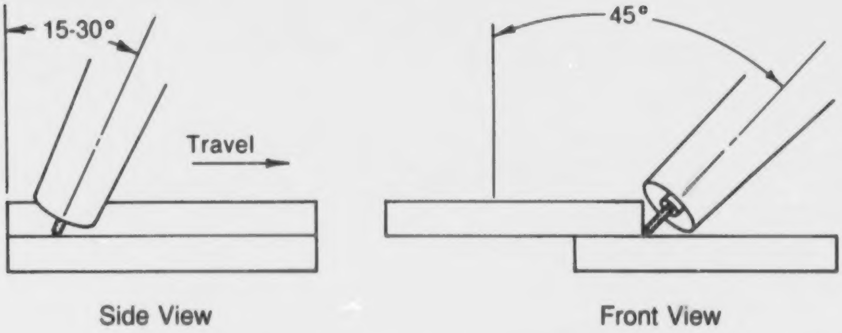
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in correct welding position.

Job Sheet 24

☐ 7. Position gun at correct angle to joint and check electrode extension.



☐ 8. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to vise and conduct a break test.

☐ 14. Inspect break for good penetration and fusion, and for defects.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld other side of the joint, if required by your instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to vise and conduct another break test.

☐ 20. Inspect break for good penetration and fusion, and for defects.

☐ 21. Have your instructor check your work.

Job Sheet 24

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
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Job Sheet 25—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

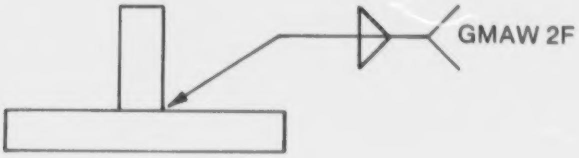
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and wire brush
Mild steel as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 25

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push or pull
9. Cleaning: Brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete setup for short-circuit transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap metal and make required adjustments.

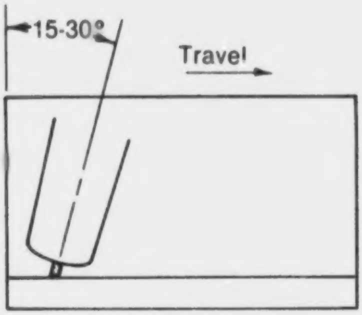
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

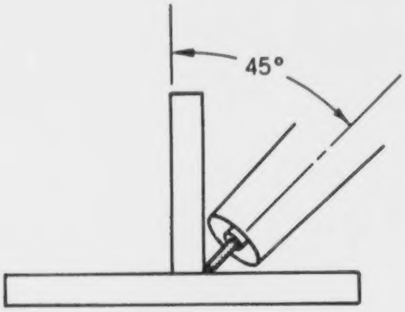
☐ 6. Position plates in correct welding position.

Job Sheet 25

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger, form a puddle on one of the tack points so that it fuses with both edges of the joint, and use a slight crescent weave to completely fuse both sides of the root opening as you weld the length of the joint.

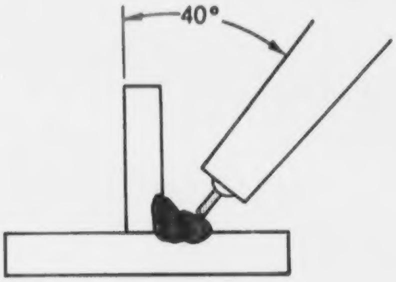
☐ 9. Crater and fill to end the weld, and put gun in safe place.

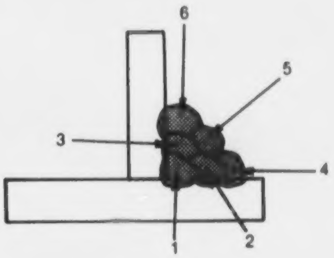
☐ 10. Clean joint with wire brush as required.

☐ 11. Inspect joint visually.

☐ 12. Check electrode extension for start of second bead, and trim as required, but do not arc excess wire off on the side of the work table.

☐ 13. Start second bead by repositioning gun angle so that second bead will overlap first bead as indicated.





☐ 14. Pull the trigger and complete second bead.

Job Sheet 25

☐ 15. Clean and inspect each bead and be sure succeeding beads overlap and fuse well with preceding beads and base metal.

☐ 16. Have your instructor check your work.

☐ 17. Continue with additional beads as directed by your instructor.

☐ 18. Have your instructor check your work.

☐ 19. Repeat procedure for the other side of the joint, if required by your instructor.

☐ 20. Have your instructor check your work.

☐ 21. Shut down and secure equipment.

☐ 22. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 26—Set Up GMAW Equipment for Spray Transfer on Aluminum

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Test bead inspection	______
Equipment shut down	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Attach ground clamp to workpiece.

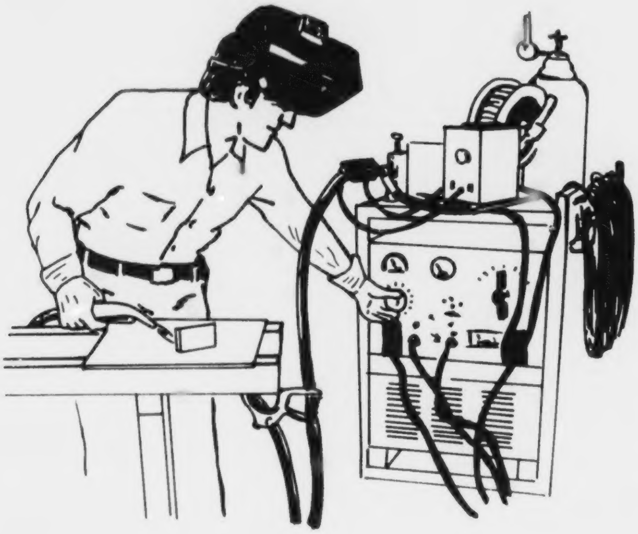
☐ 3. Turn machine on.

☐ 4. Adjust voltage and amperage to approximate settings for wire size and plate thickness, and remember that these settings are higher for spray transfer than they are for short-circuit transfer.

Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

Job Sheet 26

☐ 5. Place a piece of scrap metal on the work table so that it is behind you and you are facing the meters on the machine.



☐ 6. Turn wire feed power on.

☐ 7. Place nozzle of the gun on the piece of aluminum so that the correct electrode extension can be maintained; electrode extension should be ½" to ¾" for spray transfer.

☐ 8. Face the machine meters, keep the gun behind you, and press the trigger to create an arc.

☐ 9. Observe the voltage and amp meters quickly, and make a mental note of meter readings.

Note: If the adjustment step are too difficult, ask another student to assist you.

☐ 10. Release the trigger to break the arc.

☐ 11. Make adjustments as needed to correct voltage and amperage.

☐ 12. Run a test bead on the piece of scrap metal and listen carefully for a sound that is louder and more intense than the sound heard with the short-circuit transfer, and look for a brighter arc caused by higher amperage.

Job Sheet 26

☐ 13. Release the trigger and inspect the bead and make corrections as follows:

  a. If there is poor bead shape and undercutting, lower voltage and correct gun angle, electrode extension, and gas mixture.

  b. If there is excess spatter, increase inductance.

  c. If the bead is narrow and humpy, raise voltage and decrease wire feed speed.

  d. If the bead is flat and wide, lower voltage or increase wire feed speed.

☐ 14. Repeat procedure until settings are proper and bead has good appearance.

☐ 15. Release trigger, put gun in safe place, and inspect your bead for good penetration, good fusion, and uniform bead width with minimum spatter.

☐ 16. Have your instructor check your work.

☐ 17. Set wire speed feed to zero.

☐ 18. Turn off gas supply.

☐ 19. Depress gun trigger to relieve shielding gas pressure.

☐ 20. Allow ball in flow meter to return to zero.

☐ 21. Turn off feed control power switch, if applicable.

☐ 22. Turn off welding machine power supply.

☐ 23. Set voltage at zero.

☐ 24. Store gun, cable assembly, and ground clamp in safe place.

☐ 25. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
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Job Sheet 27—Prepare Aluminum for GMAW

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Use of portable grinder	______
Edge preparation	______
Oxide removal	______

A. Tools and materials

Aluminum as selected by instructor
Portable grinder with nonferrous grinding discs
Stainless steel brush and clean shop rags
Metal cleaner/deoxidizer solution
Personal safety clothing and safety glasses
Pliers and clamps

B. Procedure

☐ 1. Secure the workpiece with pliers and clamps.

☐ 2. Use the portable sander to remove oxide, dirt, and paint from all surfaces.

☐ 3. Grind or file edges of joints for specified edge preparation, and be sure to use nonferrous grinding discs.

☐ 4. Wet a shop rag with metal cleaner/deoxidizer, and wipe the plate to remove any oxide residue.

☐ 5. Wipe the plate dry with a clean shop rag.

☐ 6. Have your instructor check your work.

Job Sheet 27

☐ 7. Store prepared workpiece in a dry place, and weld as soon after cleaning as possible.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
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Job Sheet 28—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

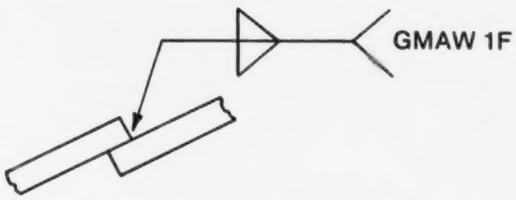
Evaluation criteria	Rating
Equipment setup and adjustments	_____
Electrode extension	_____
Welding technique	_____
Crater and fill technique	_____
Cleaning and inspection	_____

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 28

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

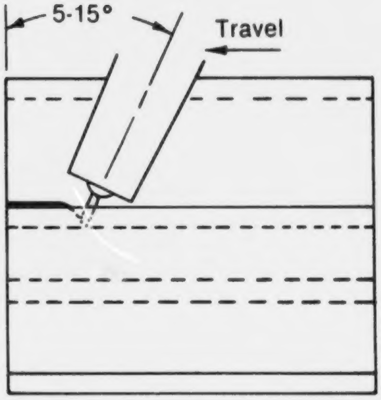
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

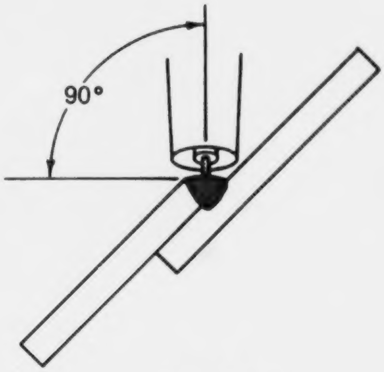
☐ 6. Position plates in correct welding position.

Job Sheet 28

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Weld other side of joint, if required by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's comments: ____________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 29—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Flat Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

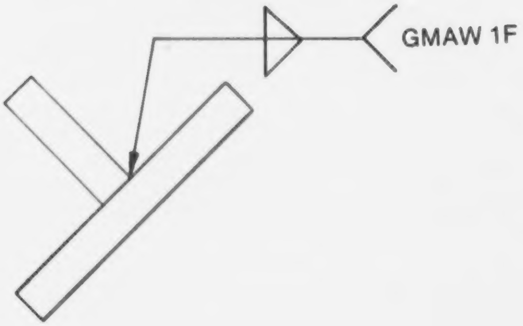
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 29

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 1F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

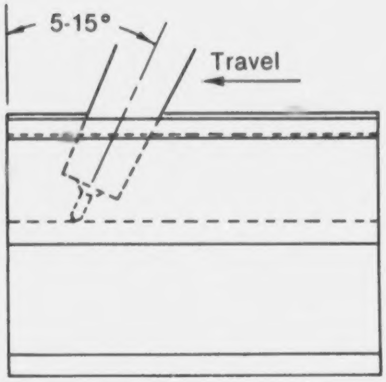
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

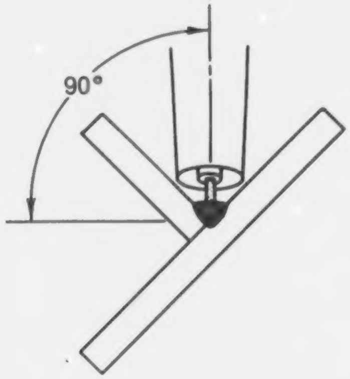
☐ 6. Position plates in correct welding position.

Job Sheet 29

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with addition beads as directed by your instructor.

☐ 14. Repeat the procedure for the other side of the joint if required by your instructor.

☐ 15. Have your instructor check your work.

☐ 16. Shut down and secure equipment.

☐ 17. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 30—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

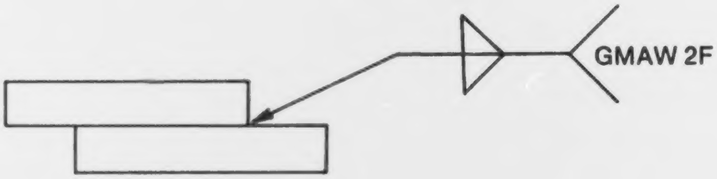
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 30

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

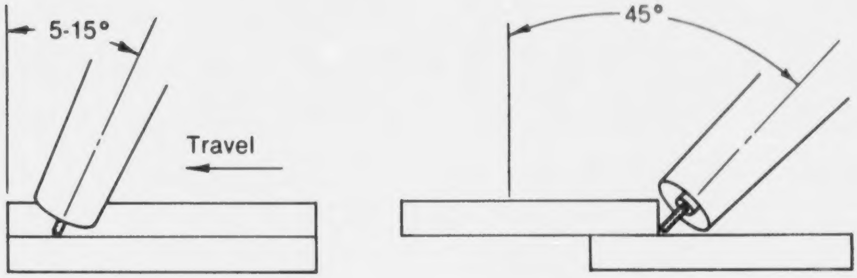
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in correct welding position.

Job Sheet 30

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View

Front View

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Weld other side of joint, if required by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 31—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

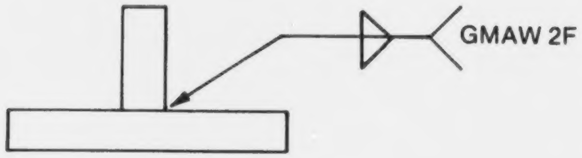
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 31

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 2F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

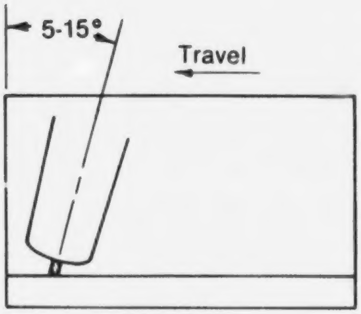
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

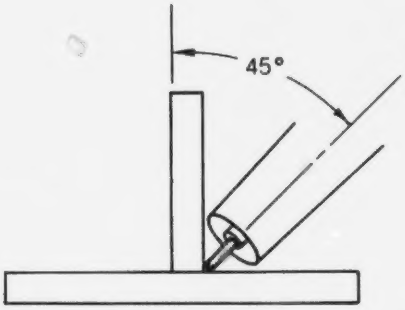
☐ 6. Position plates in correct welding position.

Job Sheet 31

☐ 7. Position gun at correct angle to joint and check electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 32—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Up Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

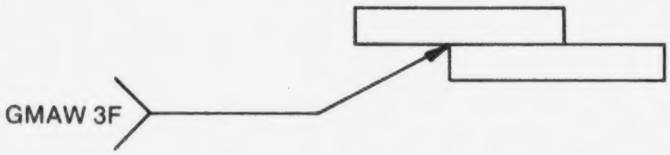
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 32

2. Wire: Per instructor

3. Wire size: Per instructor

4. Voltage/wire feed: To recommended setting

5. Shielding gas/Flow rate: Per instructor

6. Electrical: DCEP

7. Position: 3F

8. Direction of welding: Vertical up

9. Technique: Push

10. Cleaning: Stainless steel brush

11. Inspection: Visual

12. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

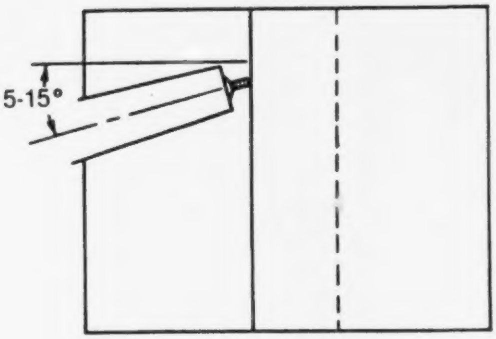
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

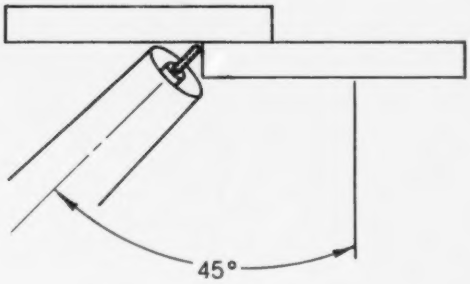
☐ 6. Position plates in correct welding position.

Job Sheet 32

☐ 7. Position gun at correct angle to joint and check electrode extension.



Front View



Top View

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Weld other side of joint, if required by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 33—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Up Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

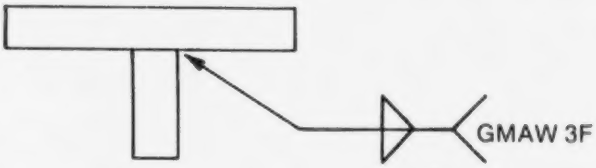
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 33

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical up
9. Technique: Push
10. Cleaning: Stainless steel brush
11. Inspection: Visual
12. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

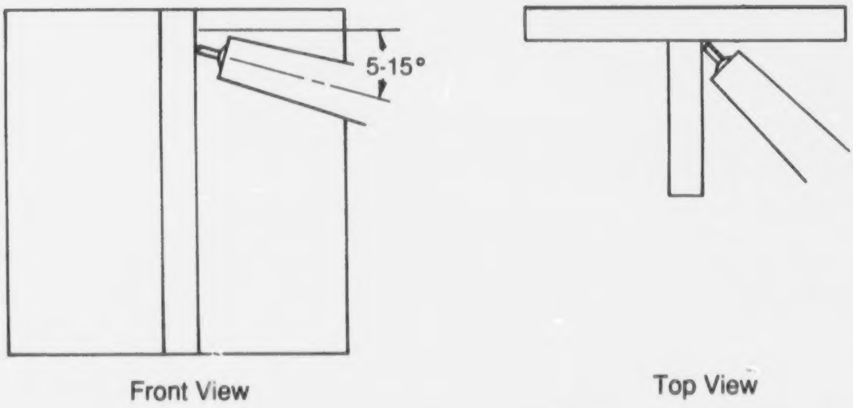
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in correct welding position.

Job Sheet 33

☐ 7. Position gun at correct angle to joint and check electrode extension.



☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 34—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Vertical Down Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

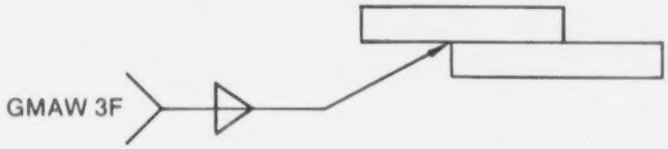
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 34

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical down
9. Technique: Pull
10. Cleaning: Stainless steel brush
11. Inspection: Visual
12. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

Note: Voltage for vertical down will need to be increased slightly more than for vertical up, and travel speed for vertical down is faster than for vertical up.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

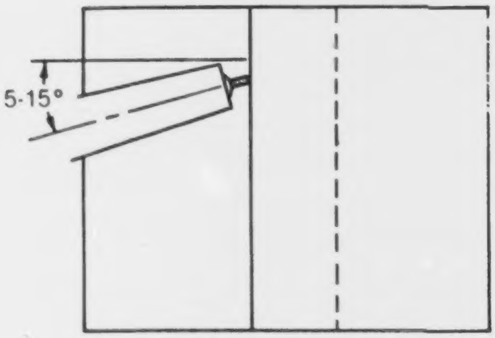
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

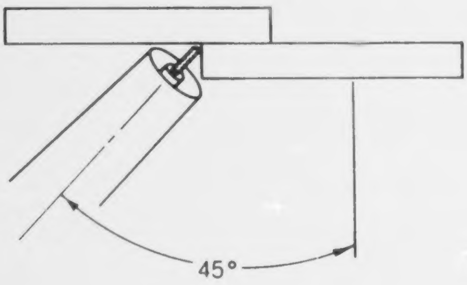
☐ 6. Position plates in correct welding position.

Job Sheet 34

☐ 7. Position gun at correct angle to joint and check electrode extension.



Front View



Top View

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Weld other side of joint, if required by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Shut down and secure equipment.

☐ 16. Check in tools and materials and clean area.

Evaluator's comments: ____________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 35—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Vertical Down Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

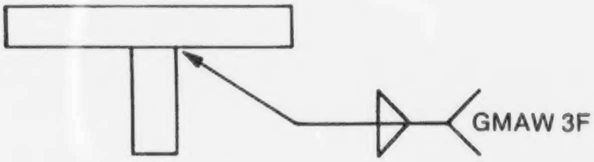
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 35

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 3F
8. Direction of welding: Vertical down
9. Technique: Pull
10. Cleaning: Stainless steel brush
11. Inspection: Visual
12. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

Note: Voltage for vertical down will need to be increased slightly more than for vertical up, and travel speed for vertical down is faster than for vertical up.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

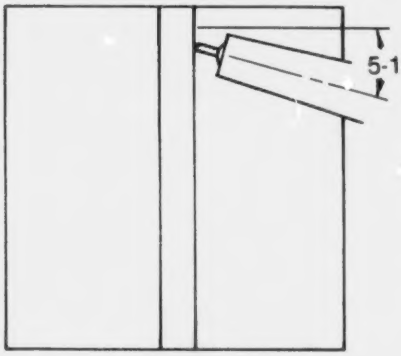
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

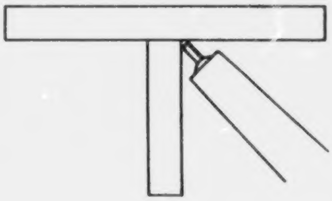
☐ 6. Position plates in correct welding position.

Job Sheet 35

☐ 7. Position gun at correct angle to joint and check electrode extension.



Front View



Top View

☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ____

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 36—Use Spray Transfer to Weld to Specifications a Fillet Weld Lap Joint on Aluminum in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

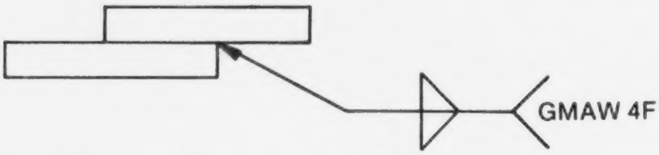
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 36

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 4F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

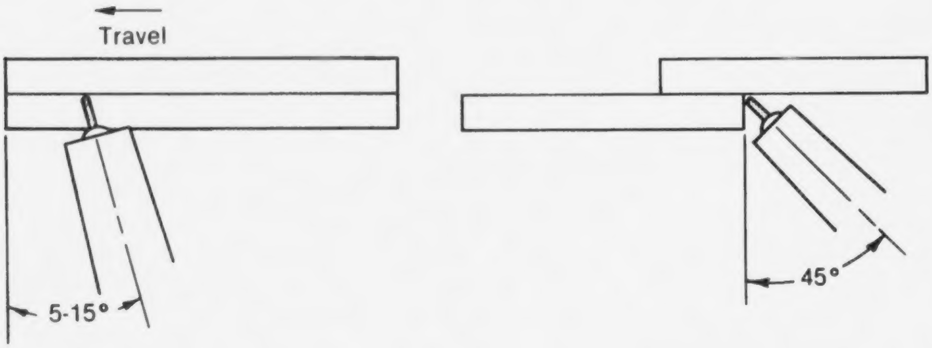
C. Procedure

1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.
2. Complete equipment setup for spray transfer as previously outlined.
3. Adjust controls for plate thickness and wire diameter.
4. Make a test bead on scrap aluminum and make required adjustments.

   Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.
5. Position plates on work table and tack both ends of joint.
6. Position plates in correct welding position.

Job Sheet 36

7. Position gun at correct angle to joint and check electrode extension.



Side View

Front View

8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

9. Crater and fill to end the weld, and put gun in safe place.

10. Clean joint with stainless steel brush as required.

11. Inspect joint visually.

12. Have your instructor check your work.

13. Weld other side of joint, if required by your instructor.

14. Have your instructor check your work.

15. Shut down and secure equipment.

16. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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GMAW Equipment, Applications, and Techniques
Unit 2

Job Sheet 37—Use Spray Transfer to Weld to Specifications a Fillet Weld T-Joint on Aluminum in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

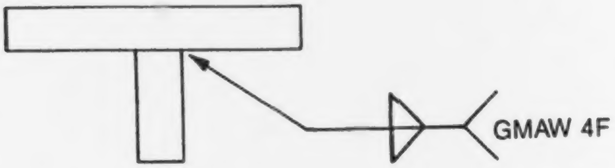
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

GMAW machine with accessories
Wire and shielding gas to specifications
Wire-cutting pliers and stainless steel wire brush
Aluminum as selected by instructor
Personal safety clothing and equipment

B. Specifications

1. Joint design and weld symbol:



Job Sheet 37

2. Wire: Per instructor
3. Wire size: Per instructor
4. Voltage/wire feed: To recommended setting
5. Shielding gas/Flow rate: Per instructor
6. Electrical: DCEP
7. Position: 4F
8. Technique: Push
9. Cleaning: Stainless steel brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Attach the flow meter regulator to the shielding gas as previously outlined and adjust the flow rate.

☐ 2. Complete equipment setup for spray transfer as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap aluminum and make required adjustments.

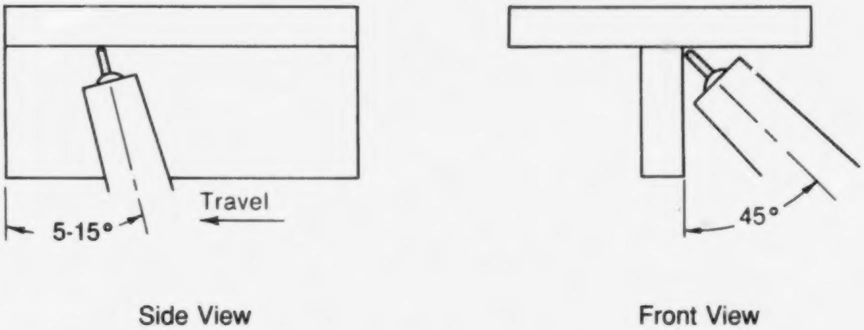
Note: Some machines have inductance and slope controls, and if you are working with such a machine, a moderate setting of the inductance control should improve arc starting and help control spatter, but no slope setting is needed in spray transfer.

☐ 5. Position plates on work table and tack both ends of joint.

☐ 6. Position plates in correct welding position.

Job Sheet 37

☐ 7. Position gun at correct angle to joint and check electrode extension.



☐ 8. Squeeze gun trigger and use a push technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and electrode extension.

☐ 9. Crater and fill to end the weld, and put gun in safe place.

☐ 10. Clean joint with stainless steel brush as required.

☐ 11. Inspect joint visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

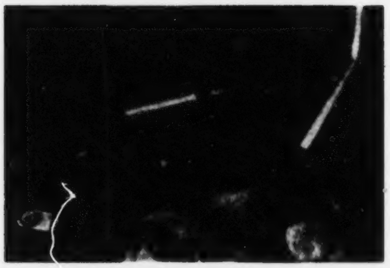
☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

____

____



Flux-Cored Arc Welding
Unit 3

Objective Sheet

Unit Objective

After completing this unit, the student should be able to set up equipment for flux-cored arc welding, and weld to specifications lap joints, T-joints, and V-groove butt joints in all positions on selected metals. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to flux-cored arc welding with their definitions.
2. Select true statements about advantages of FCAW.
3. Select true statements about limitations of FCAW.
4. Complete statements about how students benefit from learning FCAW.
5. Select true statements about equipment required for semiautomatic self-shielded FCAW.
6. Match types of flux-cored arc welding processes with their characteristics.
7. Complete statements about types of FCAW guns and their uses.
8. Solve problems about classifications for FCAW electrode wires.
9. Differentiate between electrode extension and visible electrode extension.
10. Solve problems about basic types of flux-cored wire feeders.
11. Select true statements about guidelines for using drive rolls and guide tubes.
12. Arrange in order the steps in starting an arc with the semiautomatic process.
13. Complete statements about operating variables with flux-cored electrode wires.

Objective Sheet

14. Solve problems about guidelines for preparing for FCAW applications.

15. Select true statements about guidelines for semiautomatic FCAW.

16. Complete statements about safety requirements for FCAW.

17. Solve problems about guidelines for troubleshooting FCAW problems.

18. Set up or replace wire on a flux-cored wire feeder. (Job Sheet 1)

19. Set up FCAW equipment for semiautomatic flux-cored welding. (Job Sheet 2)

20. Prepare mild steel for FCAW. (Job Sheet 3)

21. Weld to specifications a fillet weld lap joint on mild steel in the flat position. (Job Sheet 4)

22. Break test a single-pass lap joint. (Job Sheet 5)

23. Weld to specifications a fillet weld T-joint on mild steel in the flat position. (Job Sheet 6)

24. Weld to specifications a fillet weld lap joint on mild steel in the horizontal position. (Job Sheet 7)

25. Weld to specifications a fillet weld T-joint on mild steel in the horizontal position. (Job Sheet 8)

26. Weld to specifications a fillet weld lap joint on mild steel in the vertical down position. (Job Sheet 9)

27. Weld to specifications a fillet weld T-joint on mild steel in the vertical down position. (Job Sheet 10)

28. Weld to specifications a fillet weld lap joint on mild steel in the vertical up position. (Job Sheet 11)

29. Weld to specifications a fillet weld T-joint on mild steel in the vertical up position. (Job Sheet 12)

30. Weld to specifications a fillet weld lap joint on mild steel in the overhead position. (Job Sheet 13)

31. Weld to specifications a fillet weld T-joint on mild steel in the overhead position. (Job Sheet 14)

Objective Sheet

32. Weld to specifications a V-groove butt joint on mild steel in the flat position. (Job Sheet 15)

33. Weld to specifications a V-groove butt joint on mild steel in the horizontal position. (Job Sheet 16)

34. Weld to specifications a V-groove butt joint on mild steel in the vertical up position. (Job Sheet 17)

35. Weld to specifications a V-groove butt joint on mild steel in the overhead position. (Job Sheet 18)

Flux-Cored Arc Welding
Unit 3

Suggested Activities

Instructional Plan

Preparation

1. Read unit carefully and plan for instruction.
2. Review Teaching Suggestions section that follows. Plan for classroom activities.
3. Plan for enrichment of exceptional students as well as accommodation of special needs students.
4. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources section that follows.
5. Develop teaching plan. Adjust for different learning styles.
6. Make copies of Unit Evaluation Form.

Delivery and Application

7. Provide students with unit of instruction.
8. Discuss unit and specific objectives.
9. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.
10. Discuss the job sheets. Review criteria for evaluation of these activities.

Evaluation

11. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.
12. Make copies of the written test.
13. Give written test.
14. Compile job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.
15. Reteach and retest as required.

Suggested Activities

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Review welding techniques from *Gas Metal Arc Welding*. Also review how to crater and fill to end a weld. Show the similarities of the gas metal arc and flux-cored arc welding processes. Skill area: **learning to learn**.
2. Take time to demonstrate the variables discussed in Objective 13. Encourage students to keep the variables in mind as they begin the job sheets that accompany this unit. Skill area: **learning to learn**.
3. Demonstrate the procedures in the job sheets. Point out the care demanded when handling flux-cored wires, especially that flux-cored wire will flatten out much easier than the hard wires used in GMAW. Also, demonstrate how to use CO_2 as a shielding gas with FCAW, and modify job sheets as needed if you have students work with a shielding gas. Skill area: **learning to learn**.

Resources Used in Developing This Unit

1. Connor, Leonard P., ed. *Welding Handbook Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: The American Welding Society, 1987.
2. O'Brien, R. L., ed. *Welding Handbook Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: The American Welding Society, 1991.
3. *Welding & Fabricating Data Book*, 1988/89. Cleveland, OH: Penton Publishing, Inc., 1988.
4. *The Procedure Handbook of Arc Welding*, 12th Ed. Cleveland, OH: The Lincoln Electric Company, 1973.
5. Fortney, Clarence and Mike Gregory. *Gas Metal Arc Welding and Flux-Cored Arc Welding*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

Suggested Activities

Suggested Supplemental Resources

1. LIN-2, FCAW fundamentals and applications. Available in a 12 minute VHS tape. Purchase or loan.
2. LIN-4, Welding Processes, manual, semi-automatic, and full automatic. Over 300 slides with manuscript.

1 and 2 available from:

The Lincoln Electric Company
22801 St. Clair Avenue
Cleveland, OH 44117
216-481-8100

Instructions For Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Flux-Cored Arc Welding
Unit 3

Answers to Written Test

1. a. 3 d. 2
   b. 5 e. 4
   c. 1 f. 6

2. a, b, c, d

3. a, b, c, d

4. a. High deposition welding
   b. Manipulative
   c. Popular

5. b, c, d

6. a. 3
   b. 1
   d. 2

7. a. Fillet, under
   b. Heavy
   c. Air-cooled, water-cooled
   d. Air-cooled, water-cooled

8. a. 3
   b. 1
   c. 3

9. a. E
   b. V

10. a. 1
    b. 2

11. a, d, e

12. a. 2 d. 1
    b. 3 e. 5
    c. 6 f. 4

Answers to Written Test

13. a. (1) High
        (2) Excessive
        (3) Low
        (4) Low
    b. (1) Increasing
        (2) Excessive
        (3) Low
    c. (1) Excessive
        (2) Too slow
    d. (1) Increased, decreased
        (2) Increased
        (3) Short, long

14. a. 3
    b. 3

15. b

16. a. Clothing and equipment
    b. Electrical
    c. Welding gun with a smoke removal attachment
    d. Workers

17. a. 2
    b. 3

Flux-Cored Arc Welding
Unit 3

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

    ______a. An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is provided by a flux in the tubular electrode, and additional shielding may be obtained from an externally supplied gas

    ______b. A flux-cored wire electrode that protects the weld zone from contaminants with fluxing elements released from the inner core of the wire itself as the arc is made

    ______c. A flux-cored wire electrode used in the presence of a shielding gas to provide double protection and improved mechanical properties for the weld zone

    ______d. An FCAW process where welding is controlled as an operator squeezes or releases a gun trigger

    ______e. An FCAW process where welding is controlled by mechanical devices programmed for specific applications

    ______f. Having a common center or a common axis

    1. Dual-shielded
    2. Semiautomatic
    3. FCAW
    4. Automatic
    5. Self-shielded
    6. Concentric

2. Select true statements about advantages of FCAW. Place an "X" beside each true statement.

    ______a. FCAW can weld many metals over a wide thickness range, and create less distortion than SMAW.

    ______b. With FCAW, the visible arc makes for easy application with less effort on the part of the welder.

______c. FCAW is time-saving because it requires less precleaning than GMAW.

______d. FCAW produces a smooth, uniform weld with excellent appearance.

______e. FCAW has moderate stub loss so the electrode efficiency is higher than average.

3. Select true statements about limitations of FCAW. Place an "X" beside each true statement.

______a. FCAW is currently limited to welding nonferrous metals and nickel base alloys.

______b. FCAW equipment is more expensive and more complex than SMAW equipment, but increased productivity usually compensates for added FCAW costs.

______c. The FCAW wire feeder and power source must be fairly close to the point of welding.

______d. With self-shielding electrodes, FCAW is seldom bothered by breezes and drafts, but with gas shielded applications, wind can be a problem.

______e. FCAW does not require cleanup after welding, but the process does create smoke in the workplace.

4. Complete statements about how students benefit from learning FCAW. Circle the material that best completes each of the following statements.

   a. The FCAW process introduces students to (**high speed welding**) (**high deposition welding**).

   b. With FCAW, students learn (**set up**) (**manipulative**) skills for the fast welding speeds required for production-type welding.

   c. Students who master FCAW will have additional job opportunities because the FCAW process is (**the most important**) (**popular**) in industry, and its use will continue to expand.

5. Select true statements about equipment required for semiautomatic self-shielded FCAW. Place an "X" beside each true statement.

______a. The FCAW process requires a constant voltage AC power source with a minimum amperage range of 200 to 400 amps.

______b. The process requires an electrode input cable and a work cable and ground.

Written Test

______c. FCAW requires a reel of continuous electrode wire and an electrode feed unit.

______d. FCAW requires a gun and cable assembly.

6. Match types of flux-cored arc welding processes with their characteristics. Place the number of the process in the blank beside the appropriate characteristic.

______a. A modification of the manual shielded metal-arc welding process except that the covered SMAW electrode is replaced with a continuous flux-cored electrode that is fed through a gun instead of an electrode holder

______b. A modification of another process that replaces manual manipulation with programmed, mechanized components

______c. A welding process similar to both SMAW and GMAW, but different than SMAW in that CO_2 is usually used as a shielding gas in a dual function with the electrode flux, and different from GMAW in that the electrode wire is tubular instead of solid

1. Automatic self-shielded
2. Dual-shielded flux-cored
3. Semiautomatic self-shielded

7. Complete statements about types of FCAW guns and their uses. Circle the material that best completes each of the following statements.

a. Straight-nozzle guns are used for the self-shielded process, mostly on (**fillet**) (**groove**) welds and on applications where the work flows (**under**) (**in front of**) the gun.

b. Curved-nozzle guns are used in the self-shielding process, mostly for welding (**nonferrous**) (**heavy**) metals because curved nozzle guns are flexible and easy to manipulate.

c. Air-cooled and water-cooled guns are used for the gas-shielded process with (**air-cooled**) (**water-cooled**) guns generally used for operations up to 600 amps, and (**water-cooled**) (**air-cooled**) guns for operations over 600 amps.

d. (**Air-cooled**) (**Water-cooled**) guns are used for automatic processes where side shielding is required, and (**water-cooled**) (**air-cooled**) guns are used for automatic processes where concentric shielding is required.

Written Test

8. Solve problems about classifications for FCAW electrode wires. Circle the number of the best solution to each of the following problems.

   a. You are examining a spool of electrode wire and want to be certain it is designed for flux-cored welding. You should:

      (1) Look for an "E" in the number so you will know it is the right electrode wire.
      (2) Look for a 3, 4, or 6 in the number to indicate the electrode has tubular construction.
      (3) Look for a "T" in the number to indicate that the spool contains tubular flux-cored wire.

   b. You know that a welding application calls for flux-cored welding in the flat position. You should:

      (1) Check for "O" in the wire number because this indicates the wire can be used in both the flat and horizontal positions.
      (2) Check for a "1" in the wire number because like all other electrodes, this indicates the flat position.
      (3) Look for the letter "F" in the wire number because "F" indicates the flat position.

   c. You are checking for an electrode wire number identification and you find a "T-3" as the final entries. You should:

      (1) Evaluate the 3 as indicating the chemical composition of the electrode.
      (2) Evaluate the 3 as indicated not only the chemical composition of the electrode, but also a self-shielded electrode.
      (3) Evaluate the 3 as indicating not only the chemical composition of the electrode and the fact that it is a self-shielded electrode, but also an electrode to use with fast wire-feed speeds and high amperage.

9. Differentiate between electrode extension and visible electrode extension. Place an "E" beside the definition of electrode extension and a "V" beside the definition of visible electrode extension.

   ______a. The length of the electrode from the contact tip within the nozzle to the workpiece.

   ______b. The length of the electrode between the end of the nozzle and the workpiece.

Written Test

10. Solve problems about basic types of flux-cored wire feeders. Circle the number of the item that best solves each of the following problems.

    a. You're setting up for a flux-cored operation that has a long, linear weld specified. You should:

        (1) Select an integrated wire feeder on a dolly so it can be moved along the workpiece.
        (2) Select a remote wire feeder so you can keep the gun as close to the workpiece as possible.

    b. You're setting up for a flux-cored operation that requires out-of-position welding in a confined area. You should.

        (1) Select an integrated wire feeder and position it as close to the confined area as possible.
        (2) Select a remote wire feeder so you can move the control unit close to the confined area.

11. Select true statements about guidelines for using drive rolls and guide tubes. Place an "X" beside each true statement.

    ______a. Drive rolls and guide tubes for wire feeders have the wire sizes they are designed for stenciled on them; use only wires that are specified.

    ______b. Clean drive rolls and guide tubes on a weekly schedule.

    ______c. Remove accumulated dirt and shavings with a special cleaning solvent, but do not use a wire brush on a drive roll.

    ______d. Some drive rolls can be reversed, but when drive rolls are badly worn, replace them.

    ______e. When drive rolls slip while being fed into the cable, check to see if the end of the wire has been improperly prepared or check for shavings that may build up in the cable.

12. Arrange in order the steps for starting an arc with the semiautomatic process. Place a "1" beside the first step, a "2" beside the second step, and arrange other steps in their order.

    ______a. Cut the end of the wire.

    ______b. Position the tip of the electrode just off or just barely touching the base metal.

Written Test

______c. Even when a long electrode extension is desired, start with about ½" of visible electrode extension, establish the arc as outlined, then increase the stickout to the desired length.

______d. Inch the electrode out beyond the nozzle to just short of the visible electrode extension recommended for the electrode size and guide tip.

______e. Allow the arc to fully establish itself, then slowly pull the gun back until the recommended electrode extension is established.

______f. Squeeze the trigger to start the arc, but do not push the electrode into the joint as it starts to burn away.

13. Complete statements about operating variables with flux-cored electrode wires. Circle the material that best completes each of the following statements.

a. Arc voltage — When all other variables are held constant, arc voltage variations will have these effects:

(1) (**High**) (**Low**) arc voltage will produce a wider and flatter bead.

(2) (**Excessive**) (**Low**) arc voltage will tend to produce porosity.

(3) (**High**) (**Low**) voltage tends to produce a convex, ropey bead.

(4) Extremely (**low**) (**high**) voltage will cause the wire to stub on the plate or cause the wire to pierce the plate, strike the joint bottom, and push the gun up.

b. Current — When all other variables are held constant, current variations will have these effects:

(1) (**Increasing**) (**Decreasing**) current will increase melt-off and deposition rate.

(2) (**Excessive**) (**Too little**) current will produce a convex bead that looks bad and wastes metal.

(3) (**Low**) (**High**) current will result in reduced penetration.

Written Test

c. Travel speed — When all other variables are held constant, travel speed variations will have these effects:

(1) (**Excessive**) (**Slow**) travel speed makes the bead concave with uneven edges.

(2) (**Too slow**) (**Too fast**) a travel speed produces slag inclusions and a rough, uneven bead.

d. Electrode extension — When all other variables are held constant, electrode extension variations will have these effects:

(1) (**Increased**) (**Decreased**) extension decreases current and (**Increased**) (**decreased**) extension increases current.

(2) (**Increased**) (**Decreased**) extension lowers voltage across the arc, the lower arc voltage makes the bead more convex, and the tendency for porosity is reduced.

(3) (**Short**) (**Long**) extension gives greater penetration than (**short**) (**long**) extension.

14. Solve problems about guidelines for preparing for FCAW applications. Circle the number of the item that best solves each of the following problems.

a. A fellow welder is preparing to start welding on a workpiece that obviously has oil on it. The welder claims the oil will be no problem because it will burn off. You should observe:

(1) There is no problem. The oil will burn off.
(2) There is a problem. The oil will cause fumes in the work area.
(3) There is a problem. Oil on the workpiece could contribute to porosity in the weld.

b. You are sure all of you electrical settings are proper and you have the correct electrode extension, but you still get a convex or ropey-looking bead. This should be a clue to:

(1) Check the electrode wire.
(2) Check electrode extension once again.
(3) Move the ground clamp to a different location and make sure you have good metal-to-metal contact.

Written Test

15. Select true statements about guidelines for semiautomatic FCAW. Place an "X" beside each true statement.

    ______a. Obtain a good bead shape by using the lowest voltage possible without causing porosity.

    ______b. To maintain a good bead shape, always increase arc voltage when you increase current.

    ______c. Remember that travel speed is almost always slower with self-shielded flux-cored electrodes than with SMAW electrodes because of the high deposition rate.

16. Complete statements about safety requirements for FCAW. Circle the material that best completes each of the following statements.

    a. Use personal safety (**preferences**) (**clothing and equipment**) when working with FCAW equipment.

    b. Follow procedures for safely operating machines and (**gun**) (**electrical**) components at all times.

    c. When working with flux-cored wires that produce excessive smoke and fumes, use a (**welding gun with a smoke removal attachment**) (**a portable exhaust cape**).

    d. Sparks generated by the FCAW process can be excessive and erratic, so screen the welding area from nearby (**equipment**) (**workers**) and people passing by.

17. Solve problems about guidelines for troubleshooting FCAW problems. Circle the number of the item that best solves each of the following problems.

    a. You've been asked to evaluate a flux-cored weld. You should:

       (1) Look for problems with porosity. Porosity is a big FCAW problem.
       (2) Look for smooth, uniform bead appearance that FCAW should deliver.
       (3) Look for undercutting, especially if it is a V-groove weld.

    b. You've been asked to troubleshoot a welding problem that is causing weld porosity. you should:

       (1) Immediately suspect a problem with the electrode wire.
       (2) Immediately suspect a problem with a beginning welder.
       (3) Try to isolate the problem to a logical source.

***Permission to duplicate this test is granted.**

Flux-Cored Arc Welding
Unit 3

Unit Evaluation Form

Student Name ______________________________ Unit Rating __________

Job Sheet 1—Set Up or Replace Wire on a Flux-Cored Wire Feeder Rating _____

Comments: ____

____

Job Sheet 2—Set Up FCAW Equipment for Semiautomatic Flux-Cored Welding Rating _____

Comments: ____

____

Job Sheet 3—Prepare Mild Steel for FCAW Rating _____

Comments: ____

____

Job Sheet 4—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position Rating _____

Comments: ____

____

Job Sheet 5—Break Test a Single-Pass Lap Joint Rating _____

Comments: ____

____

Job Sheet 6—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position Rating _____

Comments: ____

____

Job Sheet 7—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet 8—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position Rating ______

Comments: ______________________________

Job Sheet 9—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Down Position Rating ______

Comments: ______________________________

Job Sheet 10—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Down Position Rating ______

Comments: ______________________________

Job Sheet 11—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Up Position Rating ______

Comments: ______________________________

Job Sheet 12—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Up Position Rating ______

Comments: ______________________________

Job Sheet 13—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position Rating ______

Comments: ______________________________

Job Sheet 14—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position Rating ______

Comments: ______________________________

Unit Evaluation Form

Job Sheet 15—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position Rating ______

Comments: ______

______

Job Sheet 16—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position Rating ______

Comments: ______

______

Job Sheet 17—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Up Position Rating ______

Comments: ______

______

Job Sheet 18—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position Rating ______

Comments: ______

______

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ______

______

Teacher Signature ______ Date ______

Student Signature ______ Date ______

***Permission to duplicate this form is granted.**

Flux-Cored Arc Welding
Unit 3

Teacher Supplement 1—A Brief History of FCAW

1. The FCAW process was developed because of the great potential offered by a process that could use a self-shielded electrode fed from a continuous coil supply in a mechanized process.

2. Early experiments with covered electrode coiled and fed from a reel were not successful because the flux covering tended to crack too easily.

3. In 1958, the Lincoln Electric Company introduced a process that turned the electrode wire "inside-out" so that the flux materials were inside a tubular wire.

4. Lincoln referred to their process as Innershield®, and developed self-shielding electrode wire that permitted use of higher amperages and provided greater deposition rate for production-type applications.

Flux-Cored Arc Welding
Unit 3

Information Sheet

1. **Terms and definitions**

   a. **Automatic** — An FCAW process where welding is controlled by mechanical devices programmed for specific applications

   b. **Concentric** — Having a common center or a common axis

   c. **Dual-shielded** — A flux-cored wire electrode used in the presence of a shielding gas to provide double protection and improved mechanical properties for the weld zone

   d. **FCAW (Flux-Cored Arc Welding)** — An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is provided by a flux in the tubular electrode, and additional shielding may be obtained from an externally supplied gas

      Note: Externally supplied gas or gas mixtures may or may not be used in FCAW, depending on the electrode used.

   e. **Self-shielded** — A flux-cored wire electrode that protects the weld zone from contaminants with fluxing elements released from the inner core of the wire itself as the arc is made

   f. **Semiautomatic** — An FCAW process where welding is controlled as an operator squeezes or releases a gun trigger

2. **Advantages of FCAW**

   a. FCAW can weld many metals over a wide thickness range, and create less distortion than SMAW.

   b. With FCAW, the visible arc makes for easy application with less effort on the part of the welder.

   c. FCAW is time-saving because it requires less precleaning than GMAW.

   d. FCAW produces a smooth, uniform weld with excellent appearance.

   e. FCAW has no stub loss so it offers a high electrode efficiency along with a high deposition rate.

Information Sheet

3. Limitations of FCAW

a. FCAW is currently limited to welding ferrous metals and nickel base alloys.

b. FCAW equipment is more expensive and more complex than SMAW equipment, but increased productivity usually compensates for added FCAW costs.

c. The FCAW wire feeder and power source must be fairly close to the point of welding.

d. With self-shielding electrodes, FCAW is seldom bothered by breezes and drafts, but with gas shielded applications, wind can be a problem.

e. FCAW does require cleanup after welding, and the process does create smoke in the workplace.

4. How students benefit from learning FCAW

a. The FCAW process introduces students to high deposition welding.

b. With FCAW, students learn manipulative skills for the fast welding speeds required for production-type welding.

c. Students who master FCAW will have additional opportunities because the FCAW process is popular in industry, and its use will continue to expand.

5. Equipment required for semiautomatic self-shielded FCAW

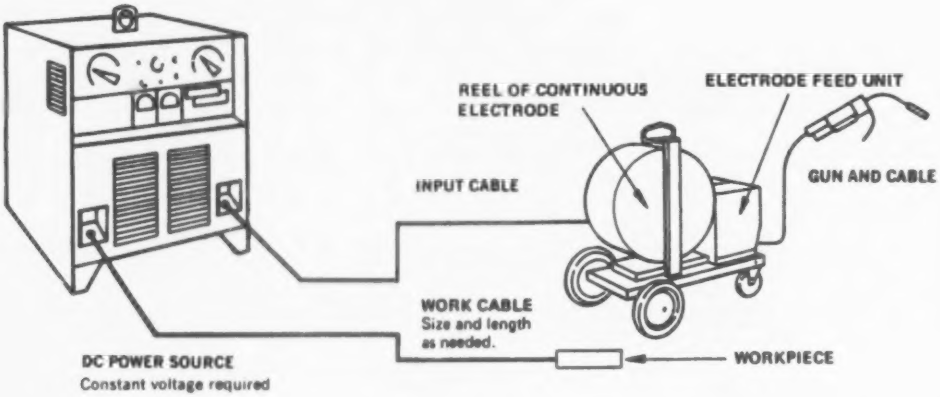
a. The FCAW process requires a constant voltage DC power source with a minimum amperage range of 200 to 400 amps.

b. The process requires an electrode input cable, a work cable, and ground.

c. FCAW requires a reel of continuous electrode wire and an electrode feed unit.

Information Sheet

d. FCAW requires a gun and cable assembly.

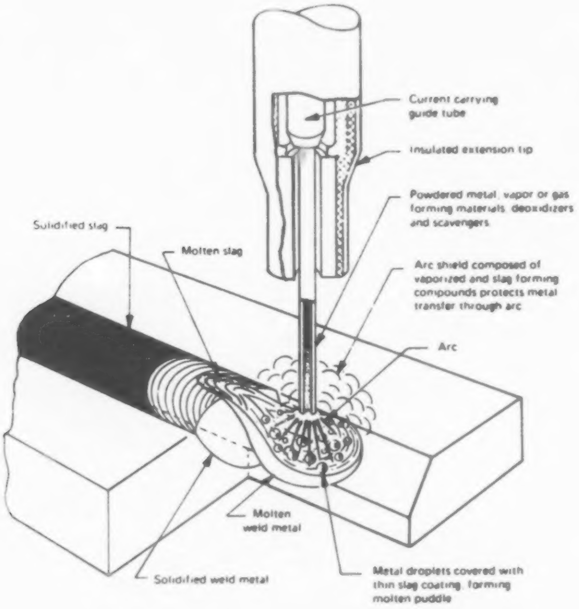

REEL OF CONTINUOUS ELECTRODE
ELECTRODE FEED UNIT
GUN AND CABLE
INPUT CABLE
WORK CABLE
Size and length as needed.
WORKPIECE
DC POWER SOURCE
Constant voltage required

Courtesy Lincoln Electric Company

Information Sheet

6. Types of flux-cored arc welding processes

a. **Semiautomatic self-shielded** — A modification of the manual shielded metal-arc welding process except that the covered SMAW electrode is replaced with a continuous flux-cored electrode that is fed through a gun instead of an electrode holder

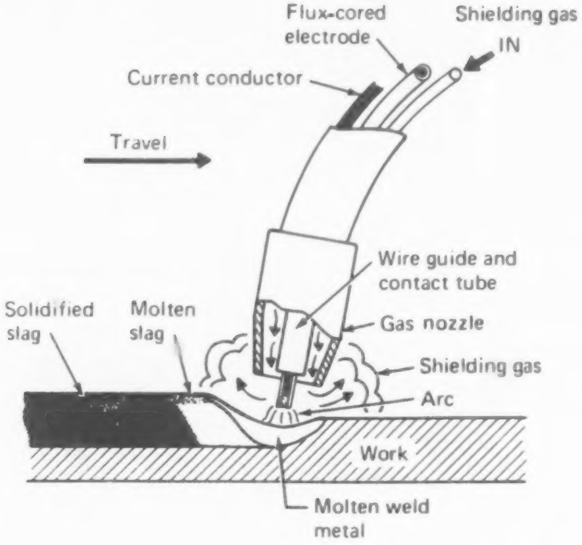

Current carrying guide tube
Insulated extension tip
Powdered metal, vapor or gas forming materials, deoxidizers and scavengers
Solidified slag
Molten slag
Arc shield composed of vaporized and slag forming compounds protects metal transfer through arc
Arc
Molten weld metal
Solidified weld metal
Metal droplets covered with thin slag coating, forming molten puddle

Courtesy Lincoln Electric Company

b. **Automatic self-shielded** — A modification of the semiautomatic self-shielded process that replaces manual manipulation with programmed, mechanized components

Information Sheet

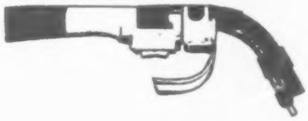
c. **Dual-shielded flux-cored** — A welding process similar to both SMAW and GMAW, but different than SMAW in that CO_2 is usually used as a shielding gas in a dual function with the electrode flux, and different from GMAW in that the electrode wire is tubular instead of solid


Flux-cored electrode
Shielding gas IN
Current conductor
Travel
Wire guide and contact tube
Solidified slag
Molten slag
Gas nozzle
Shielding gas
Arc
Work
Molten weld metal

Courtesy Lincoln Electric Company

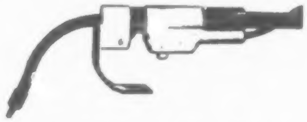
7. **Types of FCAW guns and their uses**

a. Straight nozzle guns are used for the self-shielded process, mostly on fillet welds and on applications where the work flows under the gun.



Courtesy Lincoln Electric Company

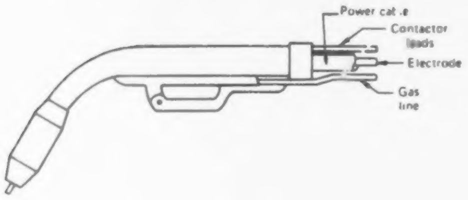
b. Curved-nozzle guns are used in the self-shielding process, mostly for welding heavy metals because curved nozzle guns are flexible and easy to manipulate.



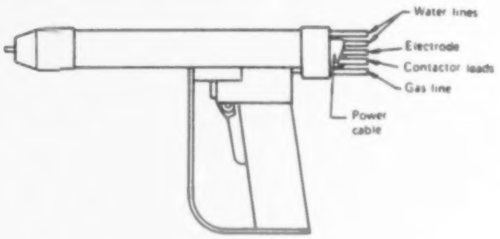
Courtesy Lincoln Electric Company

Information Sheet

c. Air-cooled and water-cooled guns are used for the gas-shielded process with air-cooled guns generally used for operations up to 600 amps, and water-cooled guns for operations over 600 amps.


Power cat .e
Contactor leads
Electrode
Gas line

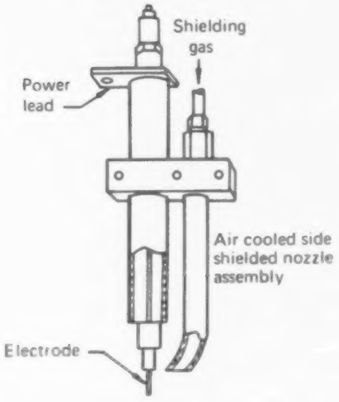
Air-cooled gun


Water lines
Electrode
Contactor leads
Gas line
Power cable

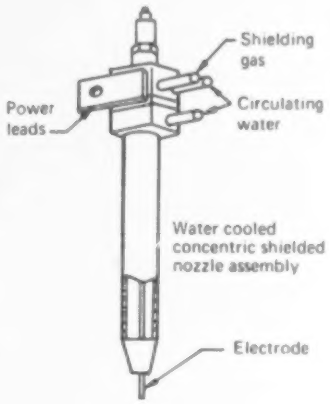
Water-cooled gun

Courtesy Lincoln Electric Company

d. Air-cooled guns are used for automatic processes where side shielding is required, and water-cooled guns are used for automatic processes where concentric shielding is required.


Shielding gas
Power lead
Air cooled side shielded nozzle assembly
Electrode

Air-cooled automatic gun


Shielding gas
Power leads
Circulating water
Water cooled concentric shielded nozzle assembly
Electrode

Water-cooled automatic gun

Courtesy Lincoln Electric Company

8. **Classifications for FCAW electrode wires**

   a. As with other AWS electrode classifications, the introductory "E" means electrode.

   b. The second two digits indicate the tensile strength and welding position.

   c. The "T" indicates the tubular construction of the flux-cored wire.

Information Sheet

d. Final numbers or number-letter combinations indicate any special chemical composition of the wire.

Example: In an E70T-4, the E means electrode, the 7 indicates the tensile strength of 70,000 psi, the 0 means the electrode may be used in the flat or horizontal positions, the T means it is tubular, and the 4 indicates the chemical composition of the electrode.

e. The "T" and following number are also used to indicate whether or not the electrode is to be used as self-shielded or dual-shielded, and ar classified as follows:

(1) Self-shielded — All T-3, T-4, T-6, T-7, T-8, T-9, and T-10 electrodes are in this class.

(2) Dual-shielded — All T-1, T-2, and T-5 electrodes are in this class.

Example: The T-3 in the E70T-3 designation indicates a self-shielded electrode.

f. The T-3 and T-6 electrodes are designed for DCEP operations with fast wire-feed speeds and high amperages for high deposition welding.

g. Other T-series electrodes are designed for DCEN with slower wire-feed speeds and lower amperages, but still provide fast travel and good penetration for special applications.

h. Other classifications include T-G which covers multi-pass electrodes not covered under specific classifications, and T-GS which covers single-pass electrodes of the same category.

Note: For typical flux-cored electrode operating variables, refer to Student Supplement 1.

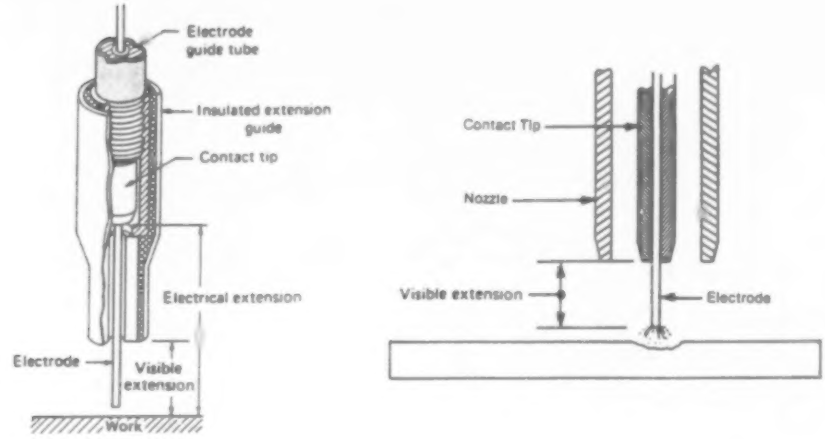
Information Sheet

9. Electrode extension and visible electrode extension

a. Electrode extension is the length of the electrode from the contact tip within the nozzle to the workpiece.

b. Visible electrode extension is the length of the electrode than can actually be seen between the end of the nozzle and the workpiece.

Note: Electrode extension is sometimes referred to as electrode stickout, and visible electrode extension is sometimes called visible stickout. When the contact tip and the end of the nozzle terminate at the same point, electrode extension and visible electrode extension are the same.

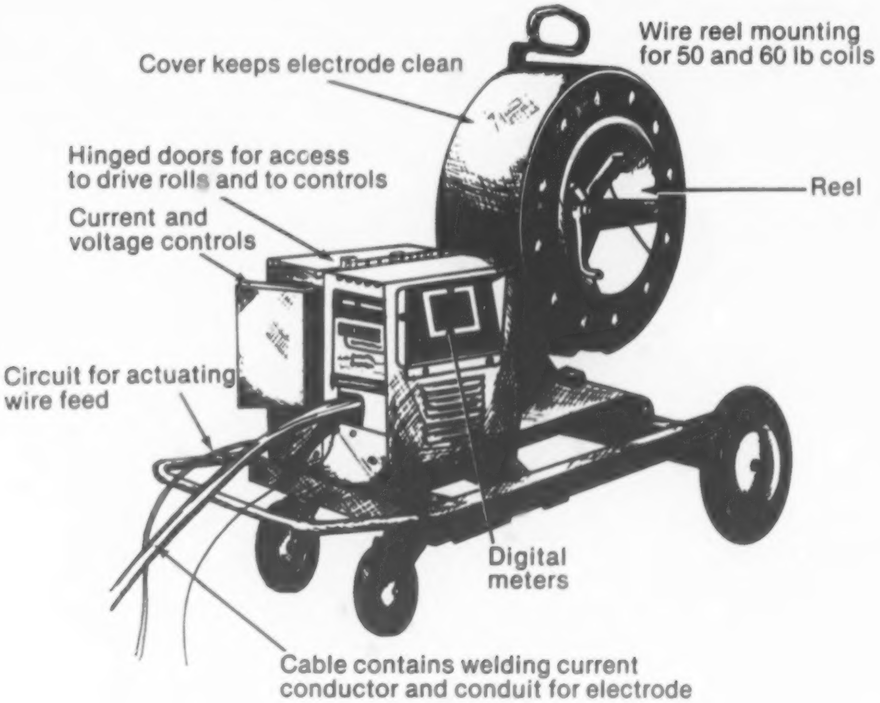

Electrode guide tube
Insulated extension guide
Contact tip
Electrical extension
Electrode
Visible extension
Work
Contact Tip
Nozzle
Visible extension
Electrode

Courtesy Lincoln Electric Company

Information Sheet

10. Basic types of flux-cored wire feeders

a. Integrated — Drive-roll and control unit are attached to the wire reel housing and the entire unit is mounted on a mobile dolly so the equipment can be moved close to the work area.


Cover keeps electrode clean
Wire reel mounting for 50 and 60 lb coils
Hinged doors for access to drive rolls and to controls
Reel
Current and voltage controls
Circuit for actuating wire feed
Digital meters
Cable contains welding current conductor and conduit for electrode

Courtesy Lincoln Electric Company

Information Sheet

b. Remote — Drive-roll and control unit are detached from the wire reel housing so longer work-to-electrode distances can be used and the control unit can be moved closer to confined work area.

Courtesy Lincoln Electric Company

11. Guidelines for using drive rolls and guide tubes

a. Drive rolls and guide tubes for wire feeders have the wire sizes for which they are designed stenciled on them; use only the wires that are specified.

b. Clean drive rolls and guide tubes after each roll of wire electrode is used.

c. Remove accumulated dirt and shavings with a wire brush, but do not use a solvent to clean drive rolls.

d. Some worn drive rolls can be reversed, but when drive rolls are badly worn, replace them.

e. When drive rolls slip while being fed into the cable, check to see if the end of the wire has been improperly prepared or check for shavings that may build up in the cable.

Information Sheet

12. Steps for starting an arc with the semiautomatic process

a. Inch the electrode out beyond the nozzle to just short of the visible electrode extension recommended for the electrode size and guide tip.

b. Cut the end of the wire.

c. Position the tip of the electrode just off or just barely touching the base metal.

d. Squeeze the trigger to start the arc, but do not push the electrode into the joint as it starts to burn away.

e. Allow the arc to fully establish itself, then slowly pull the gun back until the recommended electrode extension is established.

f. Even when a long electrode extension is desired, start with about ½″ of visible electrode extension, establish the arc as outlined, then increase the stickout to the desired length.

13. Operating variables with flux-cored electrode wires

a. Arc voltage — When all other variables are held constant, arc voltage variations will have these effects:

   (1) High arc voltage will produce a wider and flatter bead.

   (2) Excessive arc voltage will tend to produce porosity.

   (3) Low voltage tends to produce a convex, ropey bead.

   (4) Extremely low voltage will cause the wire to stub on the plate or cause the wire to pierce the plate, strike the joint bottom, and push the gun up.

b. Current — When all other variables are held constant, current variations will have these effects:

   (1) Increasing current will increase melt-off and deposition rate.

   (2) Excessive current will produce a convex bead that looks bad and wastes metal.

   (3) Low current will result in reduced penetration.

Information Sheet

c. Travel speed — When all other variables are held constant, travel speed variations will have these effects:

   (1) Excessive travel speed makes the bead concave with uneven edges.

   (2) Too slow a travel speed produces slag inclusions and a rough, uneven bead.

d. Electrode extension — When all other variables are held constant, electrode extension variations will have these effects:

   (1) Increased extension decreases current and decreased extension increases current.

   (2) Increased extension lowers voltage across the arc, the lower arc voltage makes the bead more convex, and the tendency for porosity is reduced.

   (3) Short extension gives greater penetration than long extension.

14. Guidelines for preparing FCAW applications

a. Clean the joint of scale, rust, paint, oil, and grease, and moisture, because clean surfaces help reduce porosity and make possible the faster welding speeds important for the FCAW process.

b. When making tack welds, use the same electrode recommended for the application.

c. Clamp the work cable to the workpiece so that there is good metal-to-metal contact.

   Note: Good grounding is essential because machine meters may indicate proper voltage when a bad ground is causing convex or ropey beads that are typically the result of low voltage.

d. Try different locations for the ground clamp to obtain the best weld quality.

e. Never use undersized or badly worn cables.

15. Guidelines for semiautomatic FCAW

a. Obtain a good bead shape by using the highest voltage possible without causing porosity.

b. To maintain a good bead shape, always increase arc voltage when you increase current.

Information Sheet

c. Remember that travel speed is almost always faster with self-shielded flux-cored electrodes than with stick electrodes because of the high deposition rate.

Note: Beginners with the semiautomatic FCAW process almost always use a travel speed that is too slow.

16. Safety requirements for FCAW

a. Use personal safety clothing and equipment when working with FCAW equipment.

b. Follow procedures for safely operating machines and electrical components at all times.

c. When working with flux-cored wires that produce excessive smoke and fumes, use a welding gun with a smoke removal attachment.

d. Sparks generated by the FCAW process can be excessive and erratic, so screen the welding area from nearby workers and people passing by.

17. Guidelines for troubleshooting FCAW problems

a. Inspect all welds for the smooth, uniform appearance that FCAW should deliver.

b. Try to isolate the problem to a logical source.

Example: Porosity can often be caused by insufficient flux in the core of the electrode wire, but porosity can also be caused by excessive voltage and excessive travel speed, so work with a voltage or travel speed adjustment before changing out the electrode wire.

c. As a beginner, always consider that weld discontinuities frequently result from bad practices or procedures.

d. Follow manufacturer's procedures for troubleshooting all electrical devices.

Note: For extended troubleshooting guidelines as outlined by the American Welding Society, see Student Supplement 2.

Flux-Cored Arc Welding
Unit 3

Student Supplement 1—Typical Flux-Cored Electrode Operating Variables

AWS Class	Size	Polarity	ESO	Normal Arc Voltage (Volts)	Settings Wire Feed Speed (in/min)	Approximate Current (amps)	Deposition Rate (lbs/hr)
E71T-GS	.068″	DC(–)	½″	21	185 Max.	360	8.9
				19	125	270	6.2
				17	80 Opt.	185	4.0
				15	60	140	3.0
E71T-7	.068″	DC(–)	1″	23	210 Max.	300	8.7
				21.5	155	250	6.2
				20.5	110 Opt.	200	4.2
				19	70	150	2.4
				18	55	100	1.7
E71T-7	5/64″	DC(–)	1″	24	230 Max.	400	13.2
				23	185	350	10.5
				22	145 Opt.	300	8.0
				21	110	250	5.8
				20	75	200	3.7
				19	55	150	2.4
E71T-8	3/32″	DC(–)		22	120 Max.	350	8.6
				21	110	330	7.8
				20	95 Opt.	300	6.7
				16	50	190	3.6

Flux-Cored Arc Welding
Unit 3

Student Supplement 2—FCAW Troubleshooting

Courtesy American Welding Society

Problem	Possible Cause	Corrective Action
Porosity	Low gas flow	Increase gas flowmeter setting clean spatter clogged nozzle
	High gas flow	Decrease to eliminate turbulence
	Excessive wind drafts	Shield weld zone from draft/wind
	Contaminated gas	Check gas source Check for leak in hoses/fittings
	Contaminated base metal	Clean weld joint faces
	Contaminated filler wire	Remove drawing compound on wire Clean oil from rollers Avoid shop dirt Rebake filler wire
	Insufficient flux in core	Change electrode
	Excessive voltage	Reset voltage
	Excess electrode extension	Reset electrode extension and balance current
	Insufficient electrode extension (self-shielded electrodes)	Reset electrode extension and balance current
	Excessive travel speed	Adjust speed
Incomplete Fusion or Penetration	Improper manipulation	Direct electrode to the joint root
	Improper parameters	Increase current Reduce travel speed Decrease electrode extension Reduce wire size Increase travel speed (self-shielded electrodes)
	Improper joint design	Increase root opening Reduce root face
Cracking	Excessive joint restraint	Reduce restraint Preheat Use more ductile weld metal Employ peening
	Improper electrode	Check formulation and content of flux
	Insufficient deoxidizers or inconsistent flux fill in core	
Electrode Feeding	Excessive contact tip wear	Reduce drive roll pressure
	Melted or stuck contact tip	Reduce voltage Adjust backburn control Replace worn liner
	Dirty wire conduit in cable	Change conduit liner Clean out with compressed air

Flux-Cored Arc Welding
Unit 3

Job Sheet 1—Set Up or Replace Wire on a Flux-Cored Wire Feeder

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment safety	______
Wire spool replacement	______
Wire feed final check	______

A. Tools and materials

FCAW machine with accessories
FCAW wire roll
Screwdriver, adjustable wrench, and pliers
Wire-cutting pliers and fine-cut file
Personal safety clothing and safety glasses

B. Procedure

☐ 1. Shut off input power to the power supply and wire feeder.

☐ 2. Get a firm hold on the wire near the pressure rollers, if you are replacing a partial spool.

☐ 3. Cut the wire with wire-cutting pliers near the pressure rollers.

☐ 4. Locate the small-diameter hole on the outside edge of the spool, put the end of the cut wire into it, and tie the loose end.

☐ 5. Remove the nozzle from the FCAW gun.

☐ 6. Press the gun trigger switch and run the cut wire past the pressure rollers, and then release the gun trigger switch.

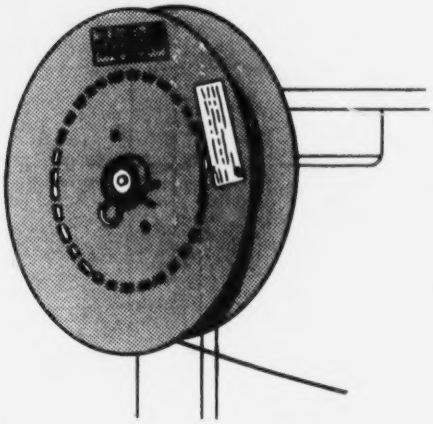
☐ 7. Pull the remaining wire through the cable and dispose of it, if you are replacing a partial or empty spool.

☐ 8. Remove the contact tip.

Job Sheet 1

☐ 9. Remove the retaining collar that holds the spool in place by loosening the thumb screw or removing the cotter pin that secures it.

Note: Different manufacturers of FCAW equipment use various methods of spool attachment.



☐ 10. Remove the empty or partially used spool from the spindle and set it aside.

Note: The following procedures are for initial setup or for wire replacement.

☐ 11. Locate the end of the wire on the new spool and position the new spool so that the wire will feed from the bottom of the spool into the wire feeder.

Caution: Do not remove the free end of the wire from the retaining hole where it is secure or you will have wire all over the place.

☐ 12. Place the new spool of wire onto the spindle and make sure the drag brake pin slips into the proper hole.

☐ 13. Place the retaining collar back on the spindle, force it tightly against the reel, and tighten the thumb screw or replace the cotter pin that secures it.

Job Sheet 1

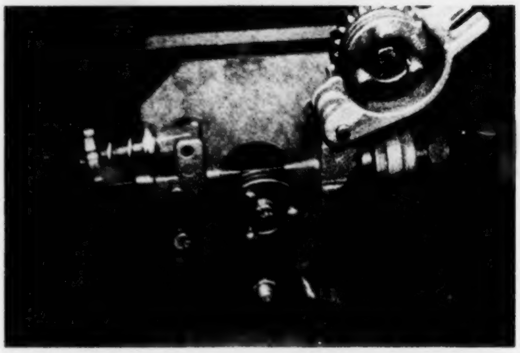
☐ 14. Locate the end of the wire on the spool, free it from the retaining hold, and clip the end of the wire.

Caution: Hang on to the free end of the wire firmly throughout this procedure.

☐ 15. Use a file to smooth the sharp end of the wire.

☐ 16. Release pressure on the top rollers by loosening with a screwdriver or thumb screw knob, then raise the top roller.

☐ 17. Guide the clean, free end of the wire through the insulated input guide and use both hands to push and pull the wire across the top of the bottom feed roller and through the insulated output guide.



☐ 18. Continue pushing and pulling the wire until it moves into and through the wire feed power assembly 2″ to 3″.

Caution: Do not force the wire into the wire feed assembly, just work it back and forth until it fits smoothly.

☐ 19. Bring top feed roll down so that the wire lies in the groove between both the rollers.

Job Sheet 1

☐ 20. Use a screwdriver, or thumb screw, to tighten the pressure adjusting screw to provide operating pressure between the bottom and top rollers.

> **Caution: Do not overtighten the adjusting screw and cause the wire to flatten out.**

☐ 21. Turn power supply on and wire feed power on.

☐ 22. Position gun so that the cable conduit between the wire feeder and gun is straight.

Note: Use the wire-inch for the following adjustment because it will help keep from shorting out the gas diffuser.

☐ 23. Turn the wire-inch on and feed the wire through the cable conduit to the gun while testing tension on the feed roller with the following procedures:

- a. Pinch the wire with finger pressure just ahead of the insulated input guide.
- b. If a slight pinching presssure will stop the wire from feeding through, the tension is probably all right.
- c. If a slight pinching pressure will not stop the wire from feeding through, the tension is probably too much.

☐ 24. Turn off power supply and wire feed supply, then replace the contact tip required for the size wire you are using, then snug the contact tip with pliers carfully.

☐ 25. Replace nozzle over contact tip.

☐ 26. Have your instructor check you work.

Note: The procedure for replacing a coil-type wire reel is essentially the same as a spool-type reel except that the coil-type reel has a spring-loaded device to secure and release it so that the reel separates into two halves in order for a replacement coil to be installed.

Job Sheet 1

☐ 27. Adjust machine for specified welding activity.

☐ 28. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

____

____

Flux-Cored Arc Welding
Unit 3

Job Sheet 2—Set Up FCAW Equipment for Semiautomatic Flux-Cored Welding

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	Rating
Ground placement	______
Electrical adjustments	______
Electrode extension	______
Test bead quality	______
Shut down procedure	______

A. Tools and materials

FCAW machine with accessories
Flux-cored wire as selected by instructor
Mild steel as selected by instructor
Screwdriver and adjustable wrench
Wire-cutting pliers and file
Chipping hammer and wire brush
Personal safety clothing and safety glasses

B. Procedure

☐ 1. Attach ground to workpiece and make sure that there is good metal-to-metal contact, and turn on shielding gas if applicable.

☐ 2. Turn machine on and adjust to correct polarity.

☐ 3. Set inductance and slope on zero if the machine is equipped with these controls.

☐ 4. Adjust voltage and wire feed to approximate settings for wire size and plate thickness.

☐ 5. Check allowable gun amperage to make sure it is high enough to handle amperage recommended for wire.

Job Sheet 2

☐ 6. Place wire in machine and feed wire through contact tip as previously outlined.

☐ 7. Place the scrap metal workpiece on the work table so that it is behind you and you are facing the meters on the machine.

☐ 8. Turn wire-feed power on, if applicable.

☐ 9. Inch the electrode out to the extension recommended for the wire size.

☐ 10. Position the tip of the electrode just off or just barely touching the workpiece.

☐ 11. Squeeze the trigger to start the arc, but do not push the electrode into the workpiece as the electrode starts to burn away.

☐ 12. Allow the arc to fully establish itself, then slowly pull the gun back until the recommended stickout is established, then turn quickly, check the meters, and make a mental note of volt and amp settings.

Note: If step 12 is too difficult, ask another student to assist you.

☐ 13. Release the trigger to break the arc.

☐ 14. Make adjustments as needed to correct voltage and amperage settings.

☐ 15. Run a test bead on the piece of scrap metal to check for proper bead shape, spatter, penetration.

☐ 16. Clean the test bead with a chipping hammer and wire brush.

☐ 17. Inspect the bead visually for good bead shape and penetration or problems with spatter or porosity.

☐ 18. Make corrections as required.

☐ 19. Repeat procedure until settings are proper and bead has good appearance.

☐ 20. Chip and brush each bead.

☐ 21. Have your instructor check your work.

☐ 22. Set the wire-feed speed control to zero.

☐ 23. Turn off feed control power switch, if applicable.

Job Sheet 2

☐ 24. Turn off welding machine power supply, and gas supply, if applicable.

☐ 25. Set voltage at zero.

☐ 26. Store gun, cable assembly, and ground clamp in a safe place.

☐ 27. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

____

____

Flux-Cored Arc Welding
Unit 3

Job Sheet 3—Prepare Mild Steel for FCAW

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Equipment safety	______
Workpiece preparation	______

A. Tools and materials

Mild steel as selected by instructor
Portable grinder and sanding attachment
Cleaner/deoxidizer solution
Pliers, clamps, and wire brush
Clean shop rags
Personal safety clothing and safety glasses

B. Procedure

☐ 1. Secure workpiece with pliers or clamps.

☐ 2. Remove mill scale, rust, dirt, and paint from all surfaces with portable sander.

☐ 3. Grind edges of joints for specified edge preparation.

☐ 4. Wire brush as required.

☐ 5. Have your instructor check your work.

☐ 6. Check in tools and materials and clean area.

Evaluator's comments: ______________________

____

____

Flux-Cored Arc Welding
Unit 3

Job Sheet 4—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Flat Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

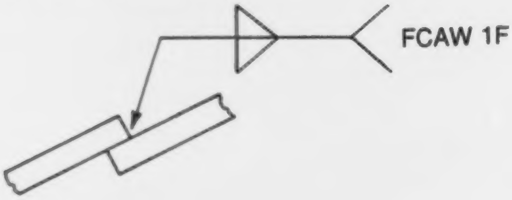
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Break test	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Bench vise and hammer
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 4

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 1F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: Break

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

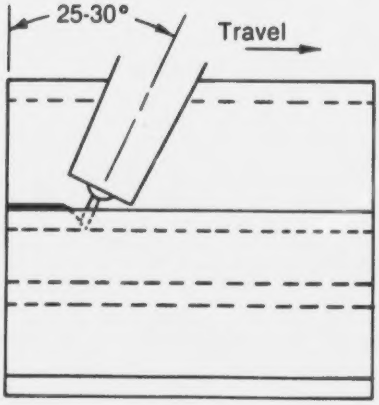
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

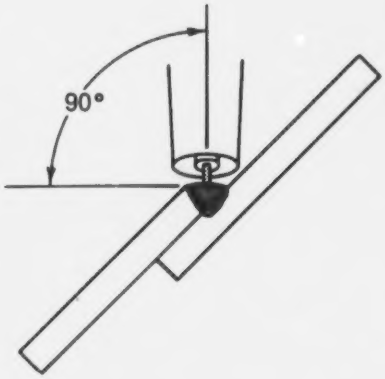
☐ 6. Position plates in correct welding position.

Job Sheet 4

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to vise and conduct a break test (see Job Sheet 5).

☐ 14. Inspect break for good penetration and fusion, and for defects.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld other side of joint, if required by instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to vise and conduct another break test.

Job Sheet 4

- ☐ 20. Inspect bead for good penetration and fusion, and for defects.
- ☐ 21. Have your instructor check your work.
- ☐ 22. Shut down and secure equipment.
- ☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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Flux-Cored Arc Welding
Unit 3

Job Sheet 5—Break Test a Single-Pass Lap Joint

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

Evaluation criteria	**Rating**
Test sample positioning	______
Bread execution	______
Weld inspection	______

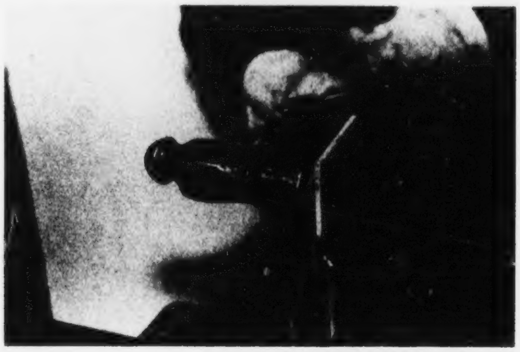
A. Tools and materials

Weld lap joint as selected by instructor
Bench vise and hammer
Pliers
Personal safety clothing and safety glasses

B. Procedure

☐ 1. Position the lap joint so that the joint runs parallel with and just above the jaws of the vise, and tighten vise.

☐ 2. Strike the plate that is not secured in the vise in a direction that will cause it to break away from the plate that is secured.



Job Sheet 5

☐ 3. Inspect break to make sure the line of the break is centered down the weld, and also inspect for good penetration and fusion, and for defects.

☐ 4. Have your instructor check your work.

☐ 5. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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Flux-Cored Arc Welding
Unit 3

Job Sheet 6—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Flat Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

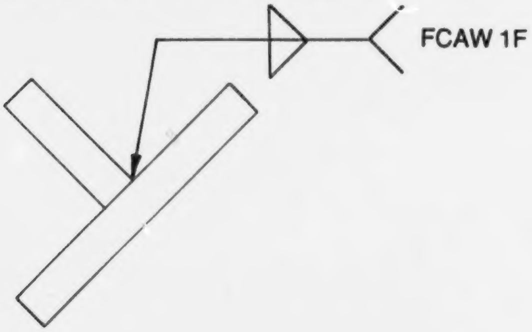
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 6

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 1F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

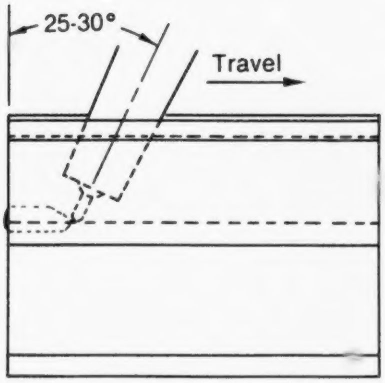
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

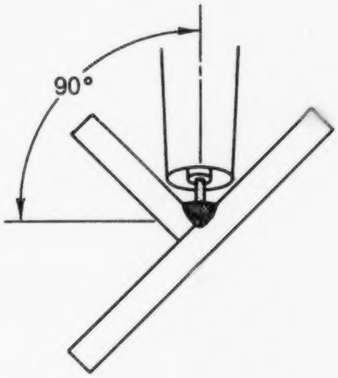
☐ 6. Position plates in correct welding position.

Job Sheet 6

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



Side View



Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ____

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Flux-Cored Arc Welding
Unit 3

Job Sheet 7—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

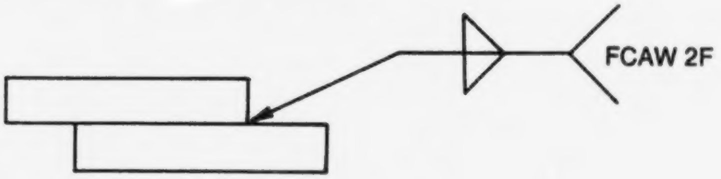
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Break test	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Bench vise and hammer
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 7

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 2F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: Break

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

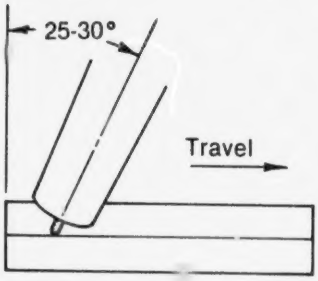
☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap metal and make required adjustments.

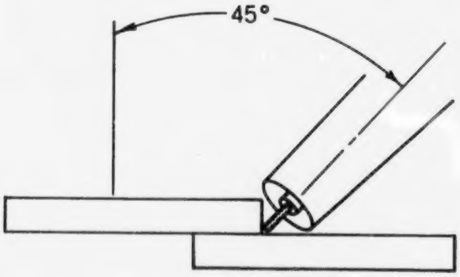
☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in correct welding position.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



Side View



Front View

Job Sheet 7

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to vise and conduct a break test.

☐ 14. Inspect break for good penetration and fusion, and for defects.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld other side of joint, if required by instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to vise and conduct another break test.

☐ 20. Inspect bead for good penetration and fusion, and for defects.

☐ 21. Have your instructor check your work.

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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Flux-Cored Arc Welding
Unit 3

Job Sheet 8—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Horizontal Position

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

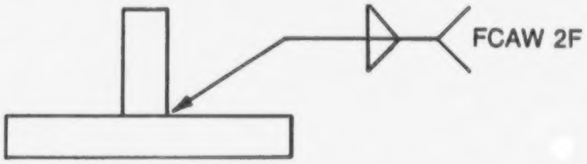
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 8

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 2F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

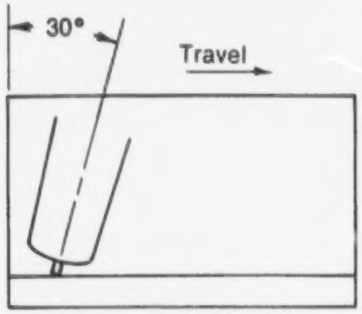
☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap metal and make required adjustments.

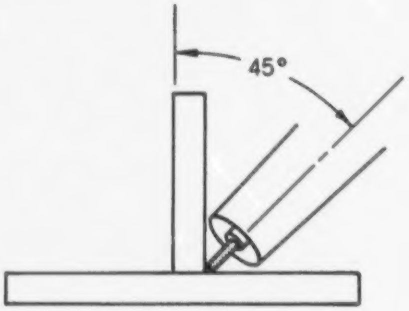
☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in correct welding position.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



Side View



Front View

Job Sheet 8

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ____

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Flux-Cored Arc Welding
Unit 3

Job Sheet 9—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Down Position

Name ________________________ Attempt Number ________

Date ________________________ Overall Rating ________

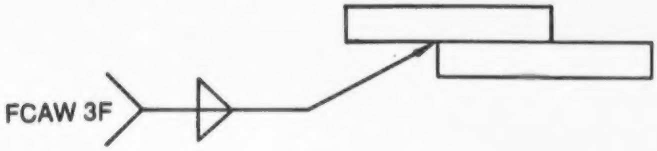
Evaluation criteria	Rating
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Break test	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Bench vise and hammer
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 9

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 3F
7. Direction of welding: Vertical down
8. Technique: Pull
9. Cleaning: Chipping hammer and wire brush
10. Inspection: Visual
11. Testing: Break

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

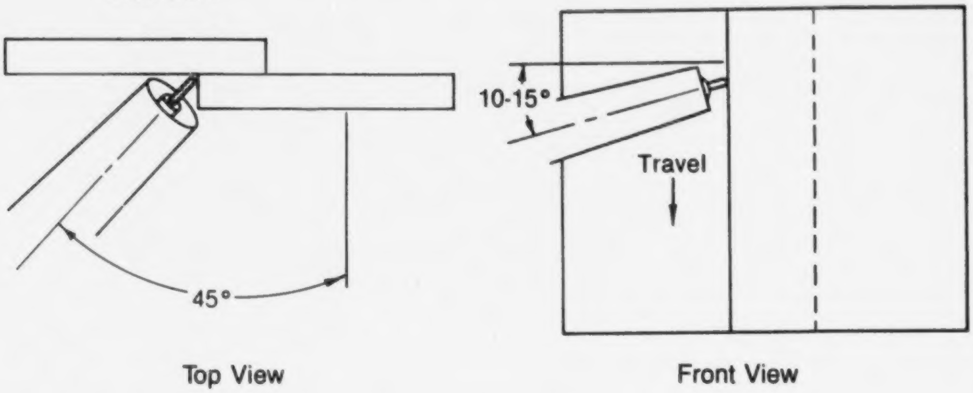
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in correct welding position.

Job Sheet 9

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to vise and conduct a break test.

☐ 14. Inspect break for good penetration and fusion, and for defects.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld other side of joint, if required by instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to vise and conduct another break test.

☐ 20. Inspect bead for good penetration and fusion, and for defects.

☐ 21. Have your instructor check your work.

Job Sheet 9

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ____

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Flux-Cored Arc Welding
Unit 3

Job Sheet 10—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Down Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

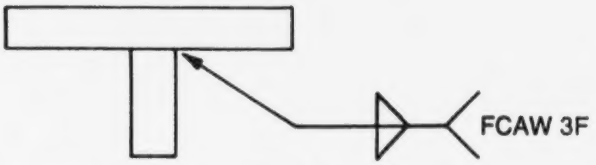
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 10

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 3F
7. Direction of welding: Vertical down
8. Technique: Pull
9. Cleaning: Chipping hammer and wire brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

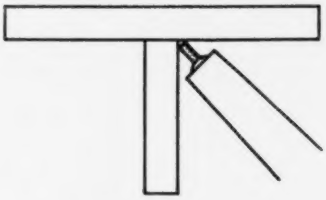
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

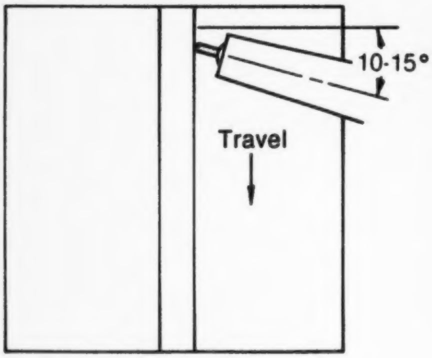
☐ 6. Position plates in correct welding position.

Job Sheet 10

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



Top View



Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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Flux-Cored Arc Welding
Unit 3

Job Sheet 11—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Vertical Up Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

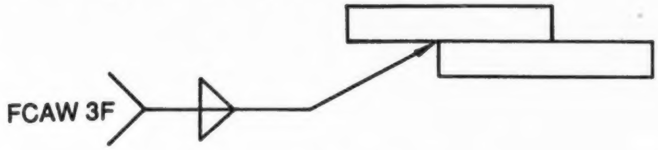
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Break test	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Bench vise and hammer
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 11

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 3F
7. Direction of welding: Vertical up
8. Technique: Push
9. Cleaning: Chipping hammer and wire brush
10. Inspection: Visual
11. Testing: Break

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

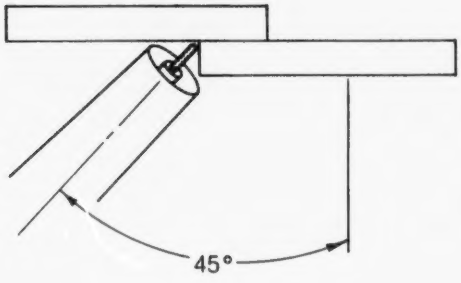
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

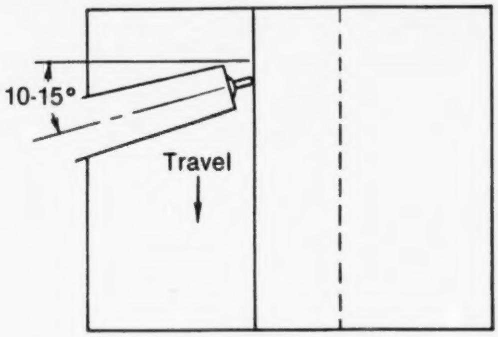
☐ 6. Position plates in correct welding position.

Job Sheet 11

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



Top View



Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to vise and conduct a break test.

☐ 14. Inspect break for good penetration and fusion, and for defects.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld other side of joint, if required by instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to vise and conduct another break test.

☐ 20. Inspect bead for good penetration and fusion, and for defects.

☐ 21. Have your instructor check your work.

Job Sheet 11

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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Flux-Cored Arc Welding
Unit 3

Job Sheet 12—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Vertical Up Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

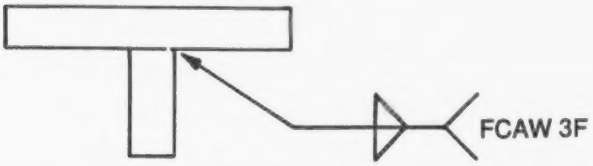
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Top View

Job Sheet 12

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 3F
7. Direction of welding: Vertical up
8. Technique: Push
9. Cleaning: Chipping hammer and wire brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

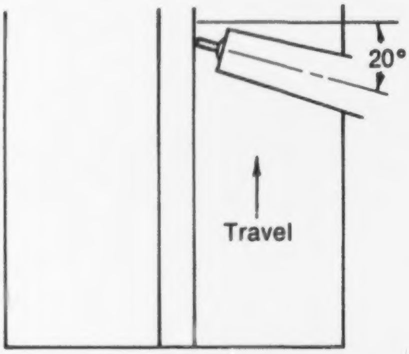
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

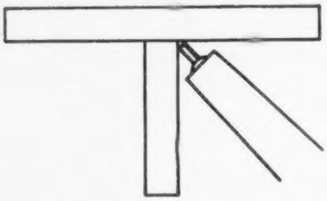
☐ 6. Position plates in correct welding position.

Job Sheet 12

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



Side View



Top View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ____

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Flux-Cored Arc Welding
Unit 3

Job Sheet 13—Weld to Specifications a Fillet Weld Lap Joint on Mild Steel in the Overhead Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

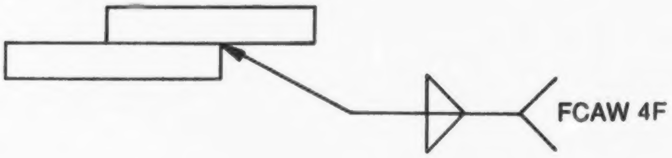
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______
Break test	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Bench vise and hammer
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 13

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 4F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: Break

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

☐ 3. Adjust controls for plate thickness and wire diameter.

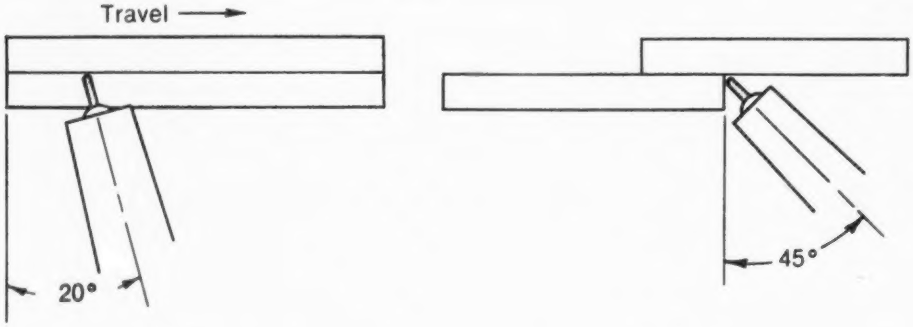
☐ 4. Make a test bead on scrap metal and make required adjustments.

☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in correct welding position.

Job Sheet 13

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



Side View

Front View

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Take plates to vise and conduct a break test.

☐ 14. Inspect bead for good penetration and fusion, and for defects.

☐ 15. Have your instructor check your work.

☐ 16. Take plates back to the work table, retack both ends, and weld other side of joint, if required by instructor.

☐ 17. Clean and visually inspect weld.

☐ 18. Have your instructor check your work.

☐ 19. Take plates back to vise and conduct another break test.

☐ 20. Inspect bead for good penetration and fusion, and for defects.

☐ 21. Have your instructor check your work.

Job Sheet 13

☐ 22. Shut down and secure equipment.

☐ 23. Check in tools and materials and clean area.

Evaluator's comments: ____________________

Flux-Cored Arc Welding
Unit 3

Job Sheet 14—Weld to Specifications a Fillet Weld T-Joint on Mild Steel in the Overhead Position

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

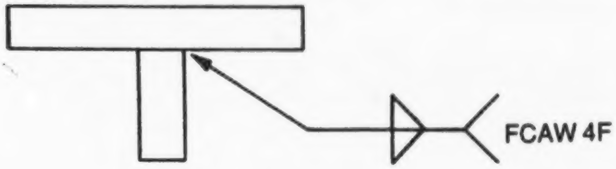
Evaluation criteria	**Rating**
Equipment setup and adjustments	______
Electrode extension	______
Welding technique	______
Crater and fill technique	______
Cleaning and inspection	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Wire-cutting pliers and file
Chipping hammer and wire brush
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 14

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 4F
7. Technique: Pull
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

C. Procedure

☐ 1. Set up wire feeder for FCAW as previously outlined.

☐ 2. Set up equipment for FCAW as previously outlined.

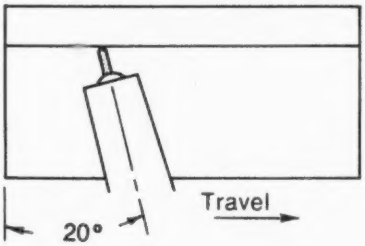
☐ 3. Adjust controls for plate thickness and wire diameter.

☐ 4. Make a test bead on scrap metal and make required adjustments.

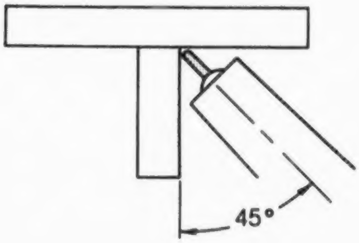
☐ 5. Position plates on work table and tack both ends of joints.

☐ 6. Position plates in correct welding position.

☐ 7. Position gun at correct angle to joint and check visible electrode extension.



Side View



Front View

Job Sheet 14

☐ 8. Squeeze gun trigger and use pull technique to weld the joint, being sure to position yourself so you can see to maintain correct gun angle and visible electrode extension.

☐ 9. Crater and fill to end the weld and put gun in safe place.

☐ 10. Clean joint with chipping hammer and wire brush.

☐ 11. Inspect weld visually.

☐ 12. Have your instructor check your work.

☐ 13. Continue with additional beads as directed by your instructor.

☐ 14. Have your instructor check your work.

☐ 15. Repeat the procedure for the other side of the joint, if required by your instructor.

☐ 16. Have your instructor check your work.

☐ 17. Shut down and secure equipment.

☐ 18. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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Flux-Cored Arc Welding
Unit 3

Job Sheet 15—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Flat Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

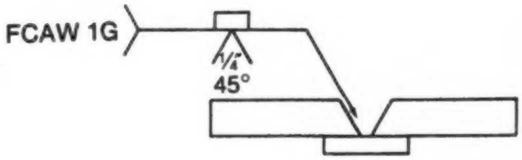
Evaluation criteria	Rating
Joint preparation	______
Equipment setup and adjustments	______
Positioning and use of backup strip	______
Welding technique	______
Crater and fill technique	______
Fill-up bead application	______
Cap pass application	______
Cleaning and inspection	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Minimum of ¼" mild steel backup strip
Wire-cutting pliers and file
Chipping hammer and wire brush
Two "C" clamps
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 15

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 1G
7. Technique: Weave
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

C. Procedure

☐ 1. Prepare plates with 22 ½° bevels.

☐ 2. Set up wire feeder for FCAW as previously outlined.

☐ 3. Set up equipment for FCAW as previously outlined.

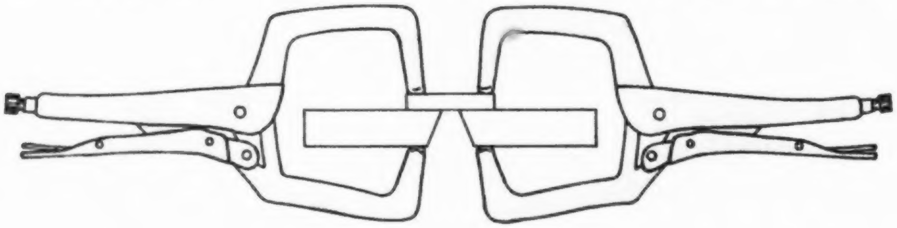
☐ 4. Adjust controls for plate thickness and wire diameter.

☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Prepare a backup plate with a ¼″ minimum thickness and long enough so that it extends 1″ beyond each edge of the joint to serve as a run-off tab.

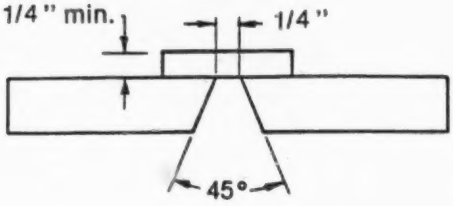
☐ 7. Position plates on a work table so that there is a ¼″ root opening in the joint.

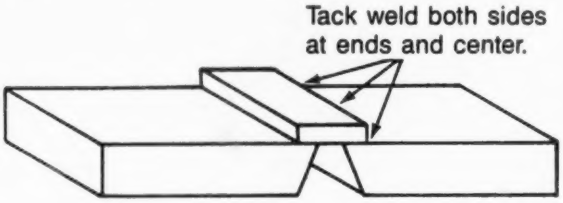
☐ 8. Place the backup strip in place and clamp it in place with two "C" clamps.



Job Sheet 15

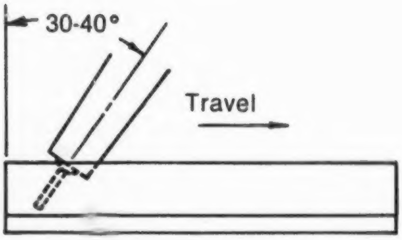
☐ 9. Tack weld the backup strip to the plates at both ends and in the center.



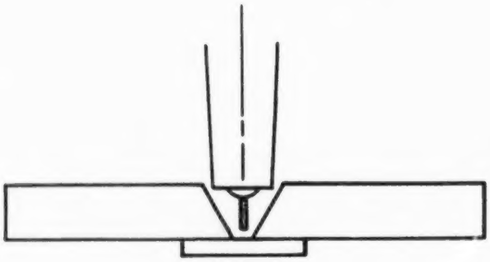


☐ 10. Position the joint and weld as specified.

☐ 11. Position gun at correct angle and check visible electrode extension.

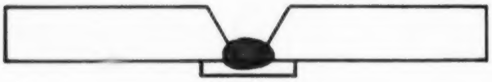


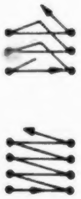
Side View



Front View

☐ 12. Squeeze the gun trigger, form a puddle to tie-in the backup strip to both beveled edges, and use a slight weaving technique to complete the first pass.





Weaving Technique Can Vary

☐ 13. Crater and fill to end the weld and put gun in safe place.

☐ 14. Clean with chipping hammer and wire brush.

☐ 15. Inspect weld visually on the front side for good tie-in on each bevel and on the back side for indications of good heat transfer through the root.

Job Sheet 15

☐ 16. Have your instructor check your work.

☐ 17. Check visible electrode extension for start of first fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 18. Reposition gun and use a weaving or stringer technique to lay a second pass over the first bead.

☐ 19. Crater and fill to end the weld and put gun in a safe place.

☐ 20. Clean and inspect second bead.

☐ 21. Have your instructor check your work.

☐ 22. Continue running weave or stringer beads and clean each pass until enough beads have been laid down to fill the joint so that it is even with the top surface of the base metals.

☐ 23. Have your instructor check your work.

☐ 24. Check visible electrode extension for start of cap bead, and trim wire as required.

☐ 25. Reposition gun and use a weaving or stringer technique again to place a cap pass on the joint.

☐ 26. Clean and inspect cap pass and have your instructor check your work.

☐ 27. Put gun in a safe place.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's comments: ____

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Flux-Cored Arc Welding
Unit 3

Job Sheet 16—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Horizontal Position

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

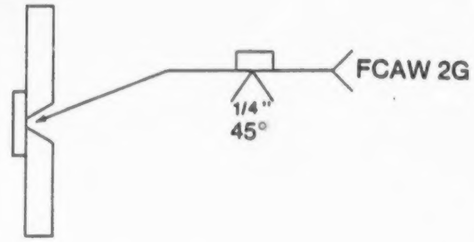
Evaluation criteria	**Rating**
Joint preparation	______
Equipment setup and adjustments	______
Positioning and use of backup strip	______
Welding technique	______
Crater and fill technique	______
Fill-up bead application	______
Cap pass application	______
Cleaning and inspection	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Minimum of ¼" mild steel backup strip
Wire-cutting pliers and file
Chipping hammer and wire brush
Two "C" clamps
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 16

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 2G
7. Technique: Weave
8. Cleaning: Chipping hammer and wire brush
9. Inspection: Visual
10. Testing: N/A

C. Procedure

☐ 1. Prepare plates with 22 ½° bevels.

☐ 2. Set up wire feeder for FCAW as previously outlined.

☐ 3. Set up equipment for FCAW as previously outlined.

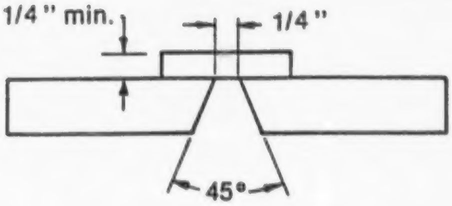
☐ 4. Adjust controls for plate thickness and wire diameter.

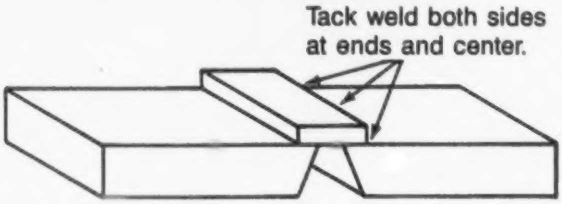
☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Prepare a backup plate with a ¼″ minimum thickness and long enough so that it extends 1″ beyond each edge of the joint to serve as a run-off tab.

☐ 7. Assemble beveled plates and backing strips so that there is a ¼″ root opening in the joint.

☐ 8. Use "C" clamps as required to secure the joint and backing, and tack weld the backup strip to the plates at both ends and in the center.

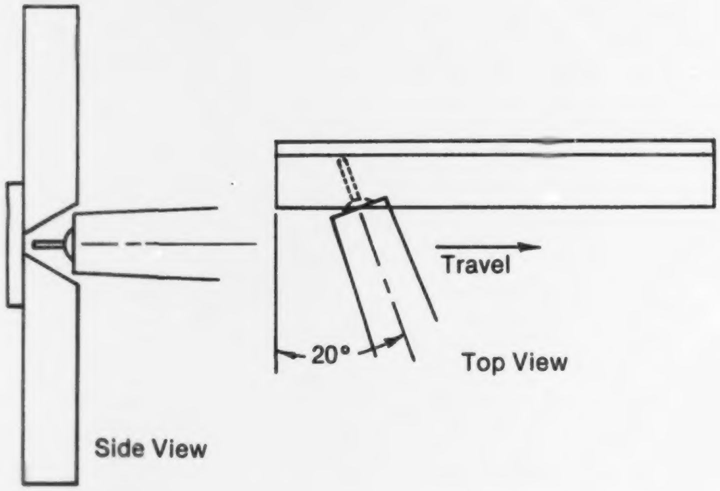




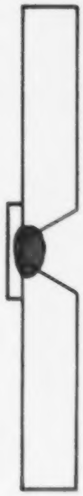
Job Sheet 16

☐ 9. Position the joint and weld as specified.

☐ 10. Position gun at correct angle and check visible electrode extension.



☐ 11. Squeeze the gun trigger, form a puddle to tie-in the backup strip to both beveled edges, and use a slight weaving technique to complete the first pass.



☐ 12. Crater and fill to end the weld and put gun in safe place.

Job Sheet 16

☐ 13. Clean with chipping hammer and wire brush.

☐ 14. Inspect weld visually on the front side for good tie-in on each bevel and on the back side for indications of good heat transfer through the root.

☐ 15. Have your instructor check your work.

☐ 16. Check visible electrode extension for start of first fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 17. Reposition gun and use a weaving or stringer technique to lay a second pass over the first bead.

☐ 18. Crater and fill to end the weld and put gun in a safe place.

☐ 19. Clean and inspect second bead.

☐ 20. Have your instructor check your work.

☐ 21. Continue running weave or stringer beads and clean each pass until enough beads have been laid down to fill the joint so that it is even with the top surface of the base metals.

☐ 22. Have your instructor check your work.

☐ 23. Check visible electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving or stringer technique again to place a cap pass on the joint.

☐ 25. Use a stair-step technique to lay additional passes to reach the upper edge.

☐ 26. Clean and inspect cap pass and have your instructor check your work.

☐ 27. Put gun in a safe place.

☐ 28. Shut down and secure equipment.

☐ 29. Check in tools and materials and clean area.

Evaluator's comments: ____

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Flux-Cored Arc Welding
Unit 3

Job Sheet 17—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Vertical Up Position

Name ______________________ Attempt Number ______

Date ______________________ Overall Rating ______

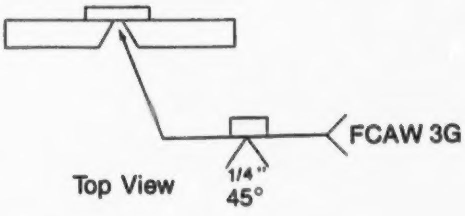
Evaluation criteria	**Rating**
Joint preparation	______
Equipment setup and adjustments	______
Positioning and use of backup strip	______
Welding technique	______
Crater and fill technique	______
Fill-up bead application	______
Cap pass application	______
Cleaning and inspection	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Minimum of ¼" mild steel backup strip
Wire-cutting pliers and file
Chipping hammer and wire brush
Two "C" clamps
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 17

2. Wire and wire size: Per instructor
3. Voltage/wire feed: To recommended setting
4. Electrical: Per electrode selection
5. Visible electrode extension: Per electrode selection
6. Position: 3G
7. Direction of welding: Vertical up
8. Technique: Weave
9. Cleaning: Chipping hammer and wire brush
10. Inspection: Visual
11. Testing: N/A

C. Procedure

☐ 1. Prepare plates with 22 ½° bevels.

☐ 2. Set up wire feeder for FCAW as previously outlined.

☐ 3. Set up equipment for FCAW as previously outlined.

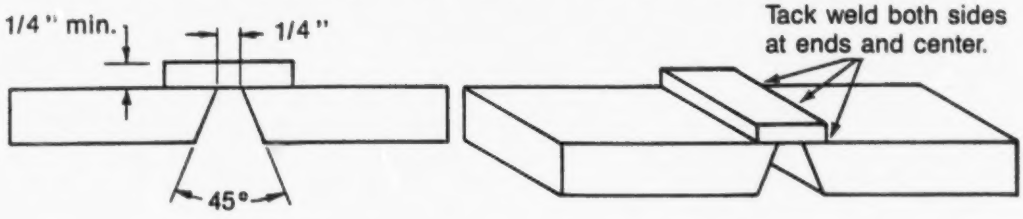
☐ 4. Adjust controls for plate thickness and wire diameter.

☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Prepare a backup plate with a ¼″ minimum thickness and long enough so that it extends 1″ beyond each edge of the joint to serve as a run-off tab.

☐ 7. Assemble beveled plates and backing strips so that there is a ¼″ root opening in the joint.

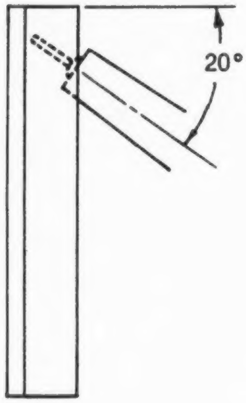
☐ 8. Use "C" clamps as required to secure the joint and backing, and tack weld the backup strip to the plates at both ends and in the center.



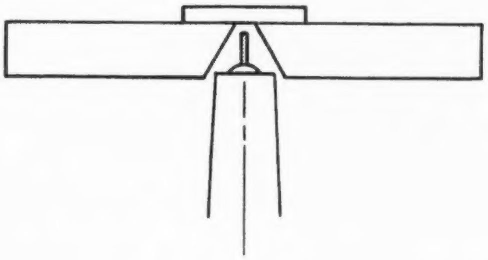
Job Sheet 17

☐ 9. Position the joint and weld as specified.

☐ 10. Position gun at correct angle and check visible electrode extension.

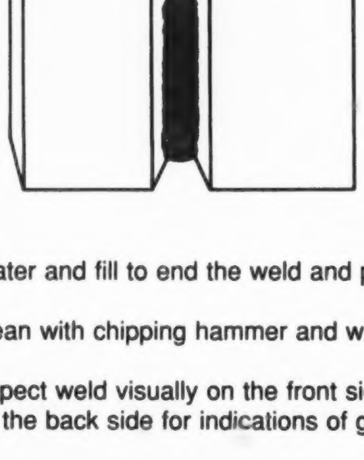


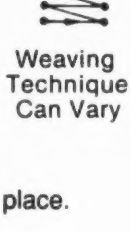
Side View



Top View

☐ 11. Squeeze the gun trigger, form a puddle to tie-in the backup strip to both beveled edges, and use a slight weaving technique to complete the first pass.





Weaving Technique Can Vary

☐ 12. Crater and fill to end the weld and put gun in safe place.

☐ 13. Clean with chipping hammer and wire brush.

☐ 14. Inspect weld visually on the front side for good tie-in on each bevel and on the back side for indications of good heat transfer through the root.

☐ 15. Have your instructor check your work.

Job Sheet 17

☐ 16. Check visible electrode extension for start of first fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 17. Reposition gun and use a weaving or stringer technique to lay a second pass over the first bead.

☐ 18. Crater and fill to end the weld and put gun in a safe place.

☐ 19. Clean and inspect second bead.

☐ 20. Have your instructor check your work.

☐ 21. Continue running weave or stringer beads and clean each pass until enough beads have been laid down to fill the joint so that it is even with the top surface of the base metals.

☐ 22. Have your instructor check your work.

☐ 23. Check visible electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use a weaving or stringer technique again to place a cap pass on the joint.

☐ 25. Clean and inspect cap pass and have your instructor check your work.

☐ 26. Put gun in a safe place.

☐ 27. Shut down and secure equipment.

☐ 28. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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Flux-Cored Arc Welding
Unit 3

Job Sheet 18—Weld to Specifications a V-Groove Butt Joint on Mild Steel in the Overhead Position

Name ______________________________ Attempt Number ________

Date ______________________________ Overall Rating ________

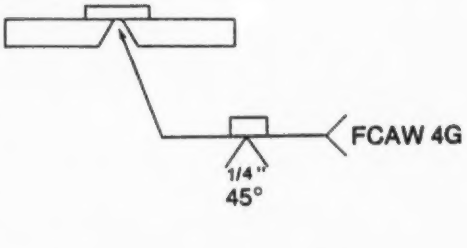
Evaluation criteria	**Rating**
Joint preparation	______
Equipment setup and adjustments	______
Positioning and use of backup strip	______
Welding technique	______
Crater and fill technique	______
Fill-up bead application	______
Cap pass application	______
Cleaning and inspection	______

A. Tools and materials

FCAW machine with accessories
FCAW wire as selected by instructor
Mild steel as selected by instructor
Minimum of ¼″ mild steel backup strip
Wire-cutting pliers and file
Chipping hammer and wire brush
Two "C" clamps
Personal safety clothing and safety glasses

B. Specifications

1. Joint design and weld symbol:



Job Sheet 18

2. Wire and wire size: Per instructor

3. Voltage/wire feed: To recommended setting

4. Electrical: Per electrode selection

5. Visible electrode extension: Per electrode selection

6. Position: 4G

7. Technique: Weave

8. Cleaning: Chipping hammer and wire brush

9. Inspection: Visual

10. Testing: N/A

C. Procedure

☐ 1. Prepare plates with 22 ½° bevels.

☐ 2. Set up wire feeder for FCAW as previously outlined.

☐ 3. Set up equipment for FCAW as previously outlined.

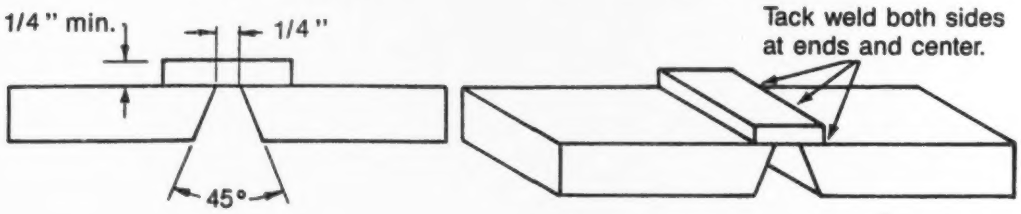
☐ 4. Adjust controls for plate thickness and wire diameter.

☐ 5. Make a test bead on scrap metal and make required adjustments.

☐ 6. Prepare a backup plate with a ¼″ minimum thickness and long enough so that it extends 1″ beyond each edge of the joint to serve as a run-off tab.

☐ 7. Assemble beveled plates and backing strips so that there is a ¼″ root opening in the joint.

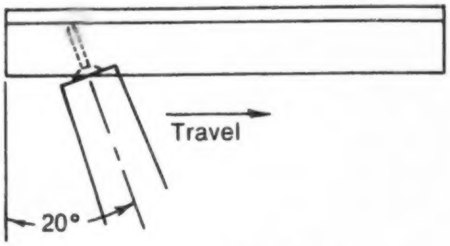
☐ 8. Use "C" clamps as required to secure the joint and backing, and tack weld the backup strip to the plates at both ends and in the center.



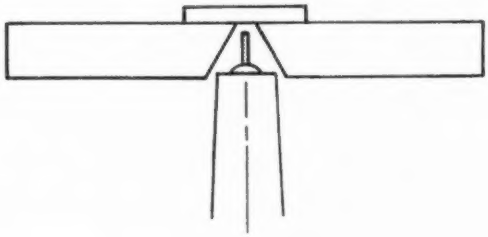
Job Sheet 18

☐ 9. Position the joint and weld as specified.

☐ 10. Position gun at correct angle and check visible electrode extension.

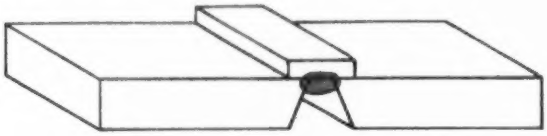


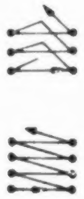
Side View



Front View

☐ 11. Squeeze the gun trigger, form a puddle to tie-in the backup strip to both beveled edges, and use a slight weaving technique to complete the first pass.





Weaving Technique Can Vary

☐ 12. Crater and fill to end the weld and put gun in safe place.

☐ 13. Clean with chipping hammer and wire brush.

☐ 14. Inspect weld visually on the front side for good tie-in on each bevel and on the back side for indications of good heat transfer through the root.

☐ 15. Have your instructor check your work.

☐ 16. Check visible electrode extension for start of first fill-up bead, and trim wire as required, but do not arc excess wire off on the side of the work table.

☐ 17. Reposition gun and use a weaving or stringer technique to lay a second pass over the first bead.

Job Sheet 18

☐ 18. Crater and fill to end the weld and put gun in a safe place.

☐ 19. Clean and inspect second bead.

☐ 20. Have your instructor check your work.

☐ 21. Continue running weave or stringer beads and clean each pass until enough beads have been laid down to fill the joint so that it is even with the top surface of the base metals.

☐ 22. Have your instructor check your work.

☐ 23. Check visible electrode extension for start of cap bead, and trim wire as required.

☐ 24. Reposition gun and use the stringer technique again to place a cap pass at the edge of the groove, then overlap passes to the other edge.

☐ 25. Clean and inspect cap pass and have your instructor check your work.

☐ 26. Put gun in a safe place.

☐ 27. Shut down and secure equipment.

☐ 28. Check in tools and materials and clean area.

Evaluator's comments: ______________________________

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